

ANALYSIS OF MODIFIABLE CARDIOVASCULAR RISK FACTORS IN UK HEALTH SERVICES

A Thesis submitted for the degree of Doctor of Philosophy
by

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Abstract

According to the World Health Organization (WHO), 17.3 million people died from cardiovascular disease worldwide in 2008 and more than 23 million people will die annually from cardiovascular disease by 2030. In the UK, the prevalence of cardiovascular disease is high—over 3 million people currently suffer from this disorder. There are a number of cardiovascular researchers in the UK population who access the National Health Services, but little evidence has been gathered from those who access the private medical insurance. According to figures from the Association of British Insurers, the number of people covered by private medical insurance rose to 6 million in 2008—about 10% of the UK's population. Due to an increasing large number of this population, there is an urgent need to investigate their health, especially cardiovascular health in this affluent group. This PhD study used a retrospective cross-sectional design, and aimed to examine the modifiable cardiovascular risk factors—BMI, waist circumference, WHR, systolic blood pressure, diastolic blood pressure, total cholesterol, HDL cholesterol, and LDL cholesterol—in a population who attended Nuffield Health, a private medical insurance company. The dataset provided by Nuffield Health is one of the largest UK datasets specifically in a commercial setting. When examining the association of socioeconomic status and cardiovascular risk factors in this affluent population, the findings show that the likelihood of having high blood pressure was lower in the most deprived area than in the least deprived area. The likelihood of having low HDL cholesterol was not significantly different between groups, but the likelihood of having high total cholesterol and LDL cholesterol was statistically significantly lower in more deprived groups. In the study assessing the effect of geographical variations on cardiovascular risk factors, no North-South effect was detected in this relatively affluent population. This finding might be generalisable to affluent populations in other European countries. In order to see the difference between this affluent population and another population from an affluent region in England, data provided by Hampshire Health Record were analysed. Although the two datasets are comparable, people living in the south England region were more likely to develop obesity and hypertension, but less likely to have elevated cholesterol and LDL, as well as low HDL, compared with those from Nuffield Health on the basis of socioeconomic status. Evidence-based population-wide policy interventions exist, and these interventions should now be urgently implemented to tackle persistent inequalities of cardiovascular health in the UK effectively.

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GLOSSARY OF TERMS

Absolute risk reduction (risk difference) is the effect of a treatment can be expressed as the difference between relevant outcomes in treatment and control groups by subtracting one rate (given by the proportion who experienced the event of interests) from the other. The reciprocal is the number needed to treat (NNT).

Analysis of variance (ANOVA) is a method of significance testing based on the ratio of between groups variance to within-groups variance. This method is used in statistical analysis if the dependent variable is continuous and the independent variable or variables are all categorical (i.e. nominal, dichotomous, or ordinal). If there is only one independent variable, the method is called one-way ANOVA. If there is more than one independent variable, the method is called *N*-way ANOVA, with *N* representing the number of independent variables.

Bias is a systematic deviation of a measurement from the “true” value, leading to either an over- or underestimation of the treatment effect. Bias can originate from many different sources, such as allocation of patients, measurement, interpretation, publication and review of data.

Bivariate statistics is descriptive statistics for the analysis of the association between two variables (e.g. contingency tables, correlations).

A person's **total body fat percentage** is the total weight of the person's fat divided by the person's weight and reflects both essential fat and storage fat. Essential fat is that amount necessary for maintenance of life and reproductive functions. The percentage for women is greater than that for men, due to the demands of childbearing and other hormonal functions. Essential fat is 2–5% in men, and 10–13% in women. Storage fat consists of fat accumulation in adipose tissue, part of which protects internal organs in the chest and abdomen. The minimum recommended total body fat percentage exceeds the essential fat percentage value reported above.

Case-control study

Patient with a certain outcome or disease are selected together with an appropriate group of controls without the outcome or disease. The groups are then compared with the populations which have been exposed to the factor under investigation.

Case series

The intervention has been used in a series of patients (it may or may not be a consecutive series) and the results reported. There is no separate control group for comparison.

Case study is a research method which focuses on the circumstances, dynamics and complexity of a single case, or a small number of cases.

Clinically important effect is an outcome that improves the clinical outlook for the patient. The recommendation made in clinical practice guidelines should be both highly statistically significant and clinically important (so that the 95% confidence interval includes clinically important effects).

Clinical trial is an experiment where the participants are patients.

Clinical outcome is an outcome for a study that is defined on the basis of the disease being studied (e.g. fracture in osteoporosis, peptic ulcer healing and relapse rates).

Cluster is a sample unit which consists of a group of elements.

Cluster sampling is probability sampling involving the selection of groupings (clusters) and selecting the sample units from the clusters.

Cohort study

Groups who have been exposed, or not exposed, to a new technology or factor of interest are followed forward in time and their rates of developing disease (or achieving, etc.) are compared.

Comparative study is a study including a comparison or control group.

Concurrent controls are controls receive the alternative interventions and undergo assessment concurrently with the group receiving the new interventions. Allocation to the intervention or control is generally not random when this term is used.

Confidence interval is an interval within which the population parameter (the true value) is expected to lie with a given degree of certainty (e.g. 95%)

Confounding

The measure of a treatment effect is distorted because of differences in variables between the treatment and control groups that are also related to the outcome. For example, if the treatment (or new intervention) is trialled in younger patients then it may appear to be more effective than the comparator, not because it is better, but because the younger patients had better outcomes.

Control group is the group in the experimental research that is not exposed to the independent variable (intervention).

Control variable is a variable used to test the possibility that an empirically observed relationship between an independent and dependent variable is spurious.

Cost-effectiveness analysis is the comparison of different programmes producing the same type of non-monetary benefit in relation to their monetary costs for an assessment of efficiency.

The **correlation** coefficient is a measure of the degree of linear association between two continuous variables. A value of +1 indicates perfect positive association, a value of -1 indicates perfect negative

association, and a value of 0 indicates no linear association. The value is highly sensitive to a few abnormal data values.

Cross-sectional study, also called prevalence study, where both exposure and outcomes are measured at the same time.

Cumulative meta-analysis

In a systematic review, the results of the relevant studies are ordered by some characteristic and sequential pooling of the trials is undertaken in increasing or decreasing order.

Degrees of freedom (df) is the numbers of independent comparisons that can be made between the members of a sample.

Descriptive statistics are used to describe the basic features of the data gathered from an experimental study in various ways. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data. It is necessary to be familiar with primary methods of describing data in order to understand phenomena and make intelligent decisions.

Epidemiology is the study of factors affecting the health and illness of populations, and serves as the foundation and logic of interventions made in the interest of public health and preventive medicine. It is considered a cornerstone methodology of public health research, and is highly regarded in evidence-based medicine for identifying risk factors for disease and determining optimal treatment approaches to clinical practice. In the work of communicable and non-communicable diseases, the work of epidemiologists range from outbreak investigation to study design, data collection and analysis including the development of statistical models to test hypotheses and the documentation of results for submission to peer-reviewed journals. Epidemiologists may draw on a number of other scientific disciplines such as biology in understanding disease processes and social science disciplines including sociology and philosophy in order to better understand proximate and distal risk factors.

Evidence-based medicine is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients.

Generalisability

This refers to the extent to which a study's results provide a correct basis for generalisation beyond the setting of the study and the particular people studied. It implies the application of the results of a study to another group or population.

Gold standard is a method, procedure or measurement that is widely regarded or accepted as being the best available. Often used to compare with new methods.

Haematology is the branch of biology (physiology), pathology, clinical laboratory, internal medicine, and pediatrics that is concerned with the study of blood, the blood-forming organs, and blood diseases.

Hazard ratio (HR)

When time to the outcome of interest is known, this is the ratio of the hazards in the treatment and control groups where the hazard is the probability of having the outcome at time t , given that the outcome has not occurred up to time t .

Health risk assessments (HRAs) are the use of questionnaires or computer programs to elicit and evaluate information concerning individuals in a clinical or industrial medical practice. Each assessed person receives information concerning estimates of his or her life expectancy and the types of interventions that are likely to have a positive impact on health or longevity.

Heart attacks happen when there is a blockage in one of the arteries in the heart.

Hydration level: the process of providing an adequate amount of water to body tissues. (hydration reaction or mineral hydration)

Incidence is the number of new events (new cases of a disease) in a defined population, within a specified period of time.

An **intervention** will generally be a therapeutic procedure such as treatment with a pharmaceutical agent, surgery, a dietary supplement, a dietary change or psychotherapy. Some other interventions are less obvious, such as early detection (screening), patient educational materials or legislation. The key characteristic is that a person or his or her environment is manipulated in the hope of benefiting that person.

Level of evidence

Study designs are often grouped into a hierarchy according to their validity, or degree to which they are not susceptible to bias. The hierarchy indicates which studies should be given most weight in an evaluation.

Lower Layer Super Output Areas (LSOAs) were first built using 2001 Census data from groups of Output Areas (typically four to six) and have been updated following the 2011 Census. They have an average of roughly 1,500 residents and 650 households. Measures of proximity (to give a reasonably compact shape) and social homogeneity (to encourage areas of similar social background) are also included.

Meta-analysis is results from several studies, identified in a systematic review, are combined and summarised quantitatively.

Meta-regression is the fitting of a linear regression model with an estimate of the treatment effect as the dependent variable and study level descriptors as the independent variables.

Nonparametric data are data for which descriptive parameters such as the mean and standard deviation cannot be obtained, because there is no measurement scale. No assumption is made about the underlying frequency distribution.

Nonrandomised cross-over design is participants in a trial are measured before and after introduction or withdrawal of the intervention and the order of introduction and withdrawal is not randomised.

Null hypothesis is the hypothesis that there is no real (true) difference between means or proportions of the groups being compared or that there is no real association between two continuous variables.

Number needed to harm (NNH)

When the treatment increases the risk of the outcome, then the inverse of the absolute risk increase is called the number needed to harm (NNH).

Number need to treat (NNT) is the number of patients with a particular condition who must receive a treatment for a prescribed period in order to prevent the occurrence of specified adverse outcomes of the condition. This number is the inverse of the absolute risk reduction.

Observational studies are any nonrandomised, nonexperimental comparison.

Outliers are extreme values that are widely deviant from the mean.

Parametric data are data for which descriptive parameters (typically the mean and standard deviation) are known and define the underlying frequency distribution of the data. The underlying distribution is often assumed to be normal, as provided in the central limit theorem.

Patient-relevant outcome is any health outcome that is meaningful to the patient. It can be the best surrogate outcome, resources provided as part of treatment, impact on productivity (indirect) or one that cannot be measured accurately (e.g. pain, suffering). Common examples include: primary clinical outcomes, quality of life and economic outcomes.

Placebo is an inert substance, indistinguishable from the active drug, which is given to the control group. This enables both subjects and researchers to remain blinded to the treatment allocation.

Prevalence is the measure of the proportion of people in a population who have some attribute or disease at a given point in time or during some time period.

Publications bias is bias caused by the results of a trial being more likely to be published if a statistically significant benefit of treatment is found.

Public Health

- The health status of the public (i.e., of a defined population).
- The organised social efforts made to preserve and improve the health of a defined population.

P value is the probability that the null hypothesis (that there is no treatment effect) is incorrectly rejected.

Qualitative research is the social research which is carried out in the field (natural settings) and analysed largely in non-statistical ways.

Quality of evidence is degree to which bias has been prevented through the design and conduct of research from which evidence is derived.

Quality of life is the degree to which a person perceives him or herself able to function physically, emotionally and socially. In a more quantitative sense, an estimate of remaining life free of impairment, disability or handicap as captured by the concept of quality-adjusted life years (QALYs).

Quantitative research is the measurement and analysis of observations in a numerical way.

Random error is the portion of variation in a measurement that has no apparent connection to any other measurement or variable, generally regarded as due to chance.

Random sampling gives each of the units in the target population a calculable and non-zero probability of being selected.

Randomisation is a process of allocating participants to treatment or control groups within a controlled trial by using a random mechanism, such as coin toss, random number table or computer-generated random numbers.

Randomised controlled trial is an experimental comparison study in which participants are allocated to treatment/intervention or control/placebo groups using a random mechanism. Participants have an equal chance of being allocated to an intervention or control group and therefore allocation bias is minimised (and virtually eliminated in very large studies).

Randomised cross-over trial

Patients are measured before and after exposure to different interventions (or placebo) which are administered in a random order (and usually blinded).

Range is a measure of dispersion which is based on the lowest and highest values observed.

Relative risk or risk ratio (RR) is ratio of the proportions in the treatment and control groups with the outcome. This expresses the risk of the outcome in the treatment group relative to that in the control group.

Relative risk reduction (RRR) is the relative reduction in risk associated with an intervention. This measure is used when the outcome of interest is an adverse event and the intervention reduces the risk. It is calculated as one minus the relative risk, or:

$$\text{RRR} = 1 - (\text{event rate in treatment group} / \text{event rate in control group})$$

Reliability, also called consistency or reproducibility, is the degree of stability that exists when a measurement is repeatedly made under different conditions or by different observers.

Risk is calculated as the proportion of persons who are unaffected at the beginning of a study period but who undergo the risk event during the study period.

Risk difference (RD) is the difference (absolute) in the proportions with the outcome between the treatment and control groups. If the outcome represents an adverse event (such as death) and the risk difference is negative (below 0) this suggests that the treatment reduced the risk – referred to as the absolute risk reduction.

Risk factor is a characteristic that, if present and active, clearly increases the probability of a particular disease in a group of persons who have the factor compared with an otherwise similar group of persons who do not. A risk factor is neither a necessary cause nor a sufficient cause of the disease.

Selection bias is error due to systematic differences in characteristics between those who are selected for study and those who are not. It invalidates conclusions that might otherwise be drawn from such studies.

Standard deviation (SD) is the square root of the variance.

Standard error (SE) is the standard deviation (SD) of a population of sample means, rather than of individual observations. The SE is calculated as the observed SD divided by the square root of N .

Statistically significant effect is an outcome for which the difference between the intervention and control groups is statistically significant (i.e. the P value is ≤ 0.05). A statistically significant effect is not necessary clinically important.

A **systematic review** is a literature review focused on a single question that tries to identify, appraise, select and synthesize all high quality research evidence relevant to that question.

t -Tests is tests that compare differences between two means.

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Author declaration

I take responsibility for all the material contained within this thesis and confirm that it is my own work.

Lin Guo

CHAPTER 1 INTRODUCTION TO THESIS

1.1 INTRODUCTION

1.1.1 Cardiovascular disease has been recognised as a global priority

Cardiovascular diseases, conditions of the heart and blood vessels, are leading causes of morbidity and mortality throughout the world. Largely diseases of lifestyle and affluence, they account for about 50% of deaths in many developed countries (Gwatkin and Guillot 1999; WHO 2007). For example, in the United States and Western European countries, coronary heart disease is the leading cause of death, also accounting for approximately 50% of deaths. In the United States alone, the prevalence of cardiovascular disease in the total population was estimated to be over 71 million in 2003 (NHLBI 2006). Meanwhile, each year in Europe, more than 4.3 million people will die from cardiovascular disease; overall mortality due to cardiovascular disease is estimated to be 28% of deaths in men and 42% in women before the age of 75 years (Nichols *et al.* 2012).

Cardiovascular disease has modifiable and non-modifiable risk factors. Non-modifiable risk factors such as age and sex are strongly associated with cardiovascular diseases. The rise of cardiovascular disease is also attributed to a number of modifiable risk factors. The leading global cardiovascular risk factors for cardiovascular disease mortality are high blood pressure (accountable for 13% of deaths globally), tobacco use (9%), high blood glucose (6%), physical inactivity (6%), and overweight and obesity (5%) (WHO 2008). These risk factors are responsible for raising the risk of cardiovascular diseases such as coronary heart disease, stroke, and ischaemic heart disease. The high prevalence of risk factors for heart diseases and stroke among young and middle-aged adults, combined with the ageing population worldwide, suggest that the prevention and management of cardiovascular diseases will continue to be a public health priority both in developing and developed countries.

Because of high prevalence in the growing population, the UN held its first high-level Meeting of the General Assembly on chronic non-communicable diseases—mainly cardiovascular diseases, cancer, diabetes, and chronic respiratory disease—in New York in September, 2011 (Beaglehole *et al.* 2010). This meeting made cardiovascular disease a global priority among

heads of states and governments and extended universal access to essential medicines and technologies for the secondary prevention of cardiovascular disease (Alleyne *et al.* 2010). The past declarations and recent global strategies provide a welcome sign that the international community is increasingly aware of the importance of cardiovascular disease. Moreover, the World Bank (2007) recently recognised the effects of cardiovascular disease in the most deprived areas of the world and acknowledged cardiovascular disease as a development priority.

The vast majority of cardiovascular mortality might be prevented through simple interventions such as smoking cessation, improved diet, and increased exercise. In the INTERHEART case-control study, Yusuf and colleagues (2004) identified nine modifiable cardiovascular risk factors that accounted for over 90% of the contribution to risk of an initial acute myocardial infarction for young men and women worldwide; cholesterol, smoking, blood pressure, diabetes, abdominal obesity (waist-to-hip ratio), psychosocial factors (including depression and stress), consumption of fruits and vegetables, consumption of alcohol, and physical activity. Chow and colleagues (2010) surveyed about 19 000 patients from 41 countries who had undergone percutaneous coronary intervention after myocardial infarction and who had answered questions about their lifestyle. They showed that patients who continued to smoke and did not adhere to diet and exercise regimens were 3.8 times more likely to suffer a myocardial infarction, stroke, or death within 6 months than were non-smokers who modified their diet and increased exercise, considering that both groups complied with their medications. Prevention and management of cardiovascular diseases will continue to be a public health priority both in developing and developed countries, but effective preventive care and a healthy lifestyle could lead to reduced prevalence of cardiovascular risk factors and, therefore, cardiovascular disease itself.

Current evidence has identified modifiable cardiovascular risk factors, and we know how evidence has translated into population effects, such as sex, socioeconomic status, region and country. Taking obesity as an example, more than 1.4 billion adults, aged 20 and older, were overweight globally. Of these overweight adults, over 200 million men and nearly 300 million women were obese (WHO 2013). In all WHO regions women were more likely to be obese than men. In the WHO regions for Africa, Eastern Mediterranean and South East Asia, women had approximately twice as much the obesity prevalence as men. The prevalence of overweight

increases with income level of countries up to upper middle income levels. The prevalence of overweight in high income and upper middle income countries was more than twice as high as low and lower middle income countries. For obesity, the difference more than triples from 7% obesity in both sexes in lower middle income countries to 24% in upper middle income countries. Women's obesity was significantly higher than men's, with the exception of high income countries where it was similar. In low and lower middle income countries, obesity among women was approximately double that among men (Global Health Observatory 2013).

1.1.2 Cardiovascular disease and associated risk factors in the UK population

According to the British Heart Foundation (2009), cardiovascular disease contributed to more than 150,000 deaths in England in 2007, accounting for nearly 34% of all deaths. Furthermore, in a recent paper in *The Lancet*, Murray and colleagues (2013) assessed the UK's health performance using the Global Burden of Diseases, Injuries, and Risk Factors (GBD) data and reported that the first ranked cause of years of life lost due to premature mortality in the UK in 2010 was ischaemic heart disease and the third ranked was stroke. Hypertension has been identified as the major risk factor for this large burden, exceeding that for alcohol and high body-mass index (BMI). The design of GBD used in the assessment of the UK's health performance is complex. GBD 2010 is the largest systematic effort to describe the epidemiology of a wide array of major diseases, injuries and risk factors ever undertaken. Millions of observations on mortality, causes of death, disease and injury prevalence and incidence, and risk factors have been collected, assessed, and collated (Murray *et al.* 2012). The advantage of the GBD approach is that consistent methods are applied to critically appraise available information on clinical conditions such as cardiovascular disease and associated risk factors, make this information comparable and systematic, estimate results from countries with incomplete data, and report on the burden of disease with the use of standardised metrics. However, it is not possible to access the raw data in the detail required to undertake a comparative analysis. Also, because of the GBD's complexity and international focus (analysis in a country-level), it would be better to find a UK-focused database to assess its cardiovascular outcomes on a regional- and area-level.

Two databases are commonly used in the UK— the Health Survey for England (HSE) and the General Practice Research Database (GPRD). HSE is an English statistical survey which is conducted annually to collect information on the basis of health and health-related behaviour of people aged 16 and above living in private households. It was originally set up in 1991 and conducted by the UK's Office for National Statistics between 1991 and 1994. It was then changed in 1994 to be conducted by the Joint Survey Unit of the National Centre for Social Research (NatCen) and the Department of Epidemiology and Public Health at University College London. Since 1995, the surveys have also included children aged 2-15 and since 2001, infants aged under 2 years. The series of Health Surveys for England was designed to monitor trends in the nation's health, to estimate the proportion of people in England who have specified health conditions, and to estimate the prevalence of certain risk factors and combinations of risk factors associated with these conditions (Health & Social Care Information Centre 2013). Each survey in the series includes core questions and measurements such as blood pressure, anthropometric measurements, etc. These data are not publicly accessible, therefore, the figures from the HSE could be used as a comparison but not for re-analysis for specific clinical outcomes. Additionally, several regional databases from the UK Public Health Observatories have appeared in publications, but these databases are not publicly accessible

GPRD is also the world's largest computerised database of anonymised longitudinal medical records from primary care. Containing comprehensive observational data from clinical practice, it is a valuable tool for academic research in a broad range of areas including clinical epidemiology, disease patterns, disease management, outcomes research, and drug utilisation. Data are collected through GP practice cross England. About 5% of the UK population is included in the GPRD, which is broadly representative of the general UK population in terms of age, sex, and geographic distributions. The database was operated by the Office for National Statistics until 1999, then took over by the Medicines and Healthcare Products Regulatory Agency (MHRA). In 2012, the new service, known as the Clinical Practice Research Datalink (CPRD), has been developed as the England-wide NHS observational and interventional research service. It has built on the research developments of the GPRD, and also the Health Research Support Service (HRSS) previously managed by the National Institute for Health Research (NIHR) Research Capability Programme. CPRD is now jointly funded by the NIHR and the MHRA. It is considered by many as the gold standard and its usage has resulted in over 890 clinical reviews and papers (Currie *et al.* 2011; Grainge *et al.* 2011; Tannen *et al.* 2009).

It has simplified governance arrangements and access to data; however, due to its affordability, size and complexity. The GPRD database requires adequate computer hardware and software, and extensive experience in data management; it is not easy for small and medium-sized research groups to access this database, especially for a PhD project (GPRD 2011). Also, the database may not contain data on every patient characteristic or disease characteristic that may be required for a study (information on occupation, employment, and socioeconomic status is not available electronically).

According to figures from the Association of British Insurers (2009), the number of people covered by private medical insurance rose to over 6 million in 2008—about 10% of the UK's population—and included an increasing number of people employed in all sectors of the workforce from manual to management. Therefore, it is worth knowing the health outcomes, especially cardiovascular, of this emerging group. One would assume that people who are able to subscribe to private medical insurance should be relatively healthy. Is this in the reality? We do not know. Little evidence has been gathered in this potentially affluent population, because most research focuses on a representative population who access public-funded NHS service. One of the reasons for not considering GPRD in this research is that the population described in these publications are mainly public sector workers, as well as low and middle socioeconomic groups.

Cardiovascular disease is linked to socioeconomic status with those in the least affluent populations showing much worse outcomes (Emberson *et al.* 2004). Improved understanding of the population effect of modifying cardiovascular risk factors may therefore be obtained by studying the behaviours of an affluent population group. After searching several databases, including PubMed/Medline, Embase, the Cochrane Library, and NHS Evidence Search, a few pieces of research have been found in the UK, focusing on one special group—commercial pilots. In their retrospective cross-sectional study involving 14 379 individuals (over 95% were men), Houston and colleagues (2011) examined the prevalence of cardiovascular risk factors among commercial aircrew and found that pilots had a significantly lower prevalence of obesity and smoking when compared with the highest income quintile of the general population and corrected for socioeconomic status. Would this evidence imply that people from a healthy subgroup of an affluent group are healthier? If so, do we know any measurements such as hypertension, cholesterol, etc. in this relatively affluent population? If not, what is the

generalisability of this evidence? Although this piece of evidence could be a useful source of debate, public health policy cannot be made on the basis of one single study.

1.1.3 Databases from Nuffield Health and Hampshire Health Record

Nuffield Health's dataset initiated an exciting opportunity in this field and established the foundation for my PhD project. Nuffield Health is a not-for-profit organisation offering 32 private hospitals, 65 gyms, and hundreds of corporate fitness facilities. It conducts health assessments at over 40 Nuffield Health centres nationwide, including their hospitals, health clubs, and medical centres. During the health assessment, the participant has a one-on-one consultation with a physiologist or doctor, depending on the type of assessment. Individual data records are collected and recorded in a dataset. The population in their datasets are mainly from higher socioeconomic groups with over 60,000 patient records, and the dataset they provided for my PhD project included information about nine cardiovascular risk factors—BMI, waist circumference, waist-to-hip ratio, systolic and diastolic blood pressure, total cholesterol, LDL, HDL, and smoking. This will be the first opportunity to assess the effect of socioeconomic status (by postcode) on a cluster of cardiovascular risk factors in a large affluent UK population.

Postal code, which could be converted to deprivation score using the Index of Multiple Deprivation 2007 (IMD 2007, see more details in chapter 2), was provided in the dataset too. It has already known that socioeconomic status is strongly linked to cardiovascular risk factors (Emberson *et al.* 2004; Huisman *et al.* 2005; Kanjilal *et al.* 2006; Kivimaki *et al.* 2007). For example, there is a strong relationship between occupational social class, high blood pressure and cholesterol level (Rose *et al.* 1981; Woodward *et al.* 1992). However, mixed results were found between income and cardiovascular risk factors (Harald *et al.* 2008; Kanjilal *et al.* 2006; Lee *et al.* 2009). At present, several area-based indices have sought to measure socioeconomic deprivation as distinct from individual socioeconomic position (Payne *et al.* 2009; Stewart *et al.* 2009; Townsend 1987). Deprivation indices are easier to apply in clinical practice than most other measurement of socioeconomic status (Blakely *et al.* 2002), and have consequently become popular among public health researchers. This is because information about individual measures of socioeconomic status may be incomplete and potentially inaccurate. The

advantage of using IMD 2007 in this research is because it is made up of seven lower layer super output area (LSOA) level domain indices. The IMD 2007 combines a total of 38 indicators, which is distributed across the seven domains, covering a range of social and economic issues to produce a deprivation score for each small area of England. The bigger the IMD 2007 score, the more deprived the LSOA. For example, the lowest IMD score is in E01016709 at Wokingham (0.37), while the highest score is in E01006755 at Liverpool (85.46). In the Nuffield Health's dataset, the IMD 2007 score ranged from 0.37 – 77.67. Liverpool has an average IMD score of 46.97, in comparison, Oxford has an average score of 18.80, and West Oxfordshire has an average score of 6.67. However, because of the exponential distribution, it is difficult to make direct comparison on the basis of IMD 2007 score itself. In order to make comparisons between LSOAs it is recommended that ranks should be used. A rank of 1 is assigned to the most deprived LSOA and a rank of 32 482 is assigned to the least deprived LSOA. On the basis of this recommendation, a comparison of the study population IMD rank (median & SD) from the Nuffield Health and National IMD rank was presented in table 1.1 below. As can be seen from the comparison below, the study population attending Nuffield Health are slightly affluent in the two least groups, and about twice as affluent than national IMD rank in the two most deprived groups (see more details of comparison in chapter 5).

Table 1.1 Comparison of the population in the Nuffield Health to the National representative population in terms of Index of Multiple Deprivation rank

	Group 1 (least deprived) n=11185	Group 2 n=10905	Group 3 n=11051	Group 4 n=11033	Group 5 (most deprived) n=11043
Study population IMD rank (Median &SD)	31,147 (1043)	27,587 (1167)	22,945 (1532)	17,215 (2046)	8,625 (4392)
National IMD rank	29,234	22,737	16,241	9,745	3,248

It has been shown that the population who attended Nuffield Health is an affluent population. We would expect that the population in Nuffield Health is relatively healthy and shows better cardiovascular outcomes than the general population in the UK. However, we could also see that there are a lot of affluent areas in the UK on the basis of IMD 2007 score, and we would

expect these populations might have similar cardiovascular outcomes as the population in the Nuffield Health. Therefore, after obtaining Nuffield Health's dataset, a contact was made with the Hampshire Health Record. The Hampshire Health Record is a joint project supported by Basingstoke and North Hampshire Foundation Trust, Hampshire Primary Care Trust, Portsmouth City Teaching Primary Care Trust, Portsmouth Hospitals NHS Trust, Southampton City Primary Care Trust, Southampton University Hospitals NHS Trust, and Winchester and Eastleigh Hospital NHS Trust. These trusts are located in the south central England region. The south central England region, where Hampshire Health Record collected the data, is relatively affluent compared with the national average. Local residents are typically very informed and influential and demand the very best from the NHS. In the Hampshire Health Record, seven cardiovascular risk factors were provided—BMI, waist circumference, systolic and diastolic blood pressure, total cholesterol, LDL, and HDL. Socioeconomic groups have been provided too in this dataset. However, postcodes were not provided, therefore, a direct comparison of socioeconomic status is not able to be compared with the general population in terms of IMD rank.

This will be a unique opportunity to compare the effect of socioeconomic status (by postcode in an area-level) on cardiovascular risk factors between the population from a relatively affluent region in the UK who have access to public NHS services and those from an affluent socioeconomic group who attended private medical screening. Using data collected in the Nuffield Health dataset and the Hampshire Health Record, this study compares the prevalence of modifiable cardiac risk factors among two relatively affluent English populations. Both datasets made my PhD project possible, and my findings are concluded in the last chapter: Chapter 9 – Conclusions.

1.2. AIMS

The aim of this thesis is to investigate the prevalence of cardiovascular outcomes in people attending private medical screening, and to compare these figures with those figures from people accessing public-funded NHS services in the Hampshire Health Record, which is coming from a relatively affluent region in the UK.

1.3 STRUCTURE

This thesis is structured in the modern style, with each chapter representing a discrete study. The central theme that links all chapters is the analysis of cardiovascular risk factors in a large UK population.

Chapter 2 lays the foundation for information that is needed to understand the series of studies analysed in the following chapters. Other fundamental principles of the underlying epistemology are also addressed in this chapter.

Chapter 3 provides a literature review for socioeconomic status, cardiovascular disease, and its associated modifiable risk factors. It will also look at intervention strategies on how to prevent the cardiovascular disease.

Chapter 4 aims to examine the prevalence of the different modifiable cardiovascular risk factors in the affluent population provided by the Nuffield Health dataset, and compares them to the general population represented in Health Survey for England 2006.

Chapter 5 is the first retrospective cross-sectional study using the dataset provided by Nuffield Health to examine the effect of area-level socioeconomic status on cardiovascular risk factors in people attending private health screening.

Chapter 6 further explore geographical variation in the prevalence of modifiable cardiovascular risk factors in people attending private health screenings in England; it compares the prevalence of modifiable cardiovascular risk factors from private medical screenings with the findings

from the HSE 2006; and estimates the risks of many modifiable cardiovascular risk factors at a regional level from dataset provided by the Nuffield Health.

Chapter 7 aims to compare the prevalence of various modifiable cardiovascular risk factors between Nuffield Health (private health screening) and Hampshire Health Record (NHS Trust), and to identify the similarities and differences of the two datasets in relation to the cardiovascular risk factors.

Chapter 8 aims to examine the association between area-level socioeconomic status and objectively measured, modifiable cardiovascular risk factors in a population from an affluent region in England who attended the public NHS, and to compare the effect of socioeconomic status on cardiovascular risk factors between people attending Nuffield Health and Hampshire Health Record.

Chapter 9 summarises the thesis and its limitations, draws conclusions, and makes recommendations for the future research.

1.4 NOTES FORMAT OF THE THESIS

This thesis is written in the modern style. Each chapter represents a discreet piece of work which is linked to the other chapters by a common theme (Figure 1.1). The project is on the basis of two datasets, Nuffield Health and Hampshire Health Record. Therefore, in some cases (chapters three, four and six & chapters seven and eight) a common methodology and population were used. To avoid the reader having to read repeated methodology, these sections are *italicised*. References have been placed at the end of each chapter.

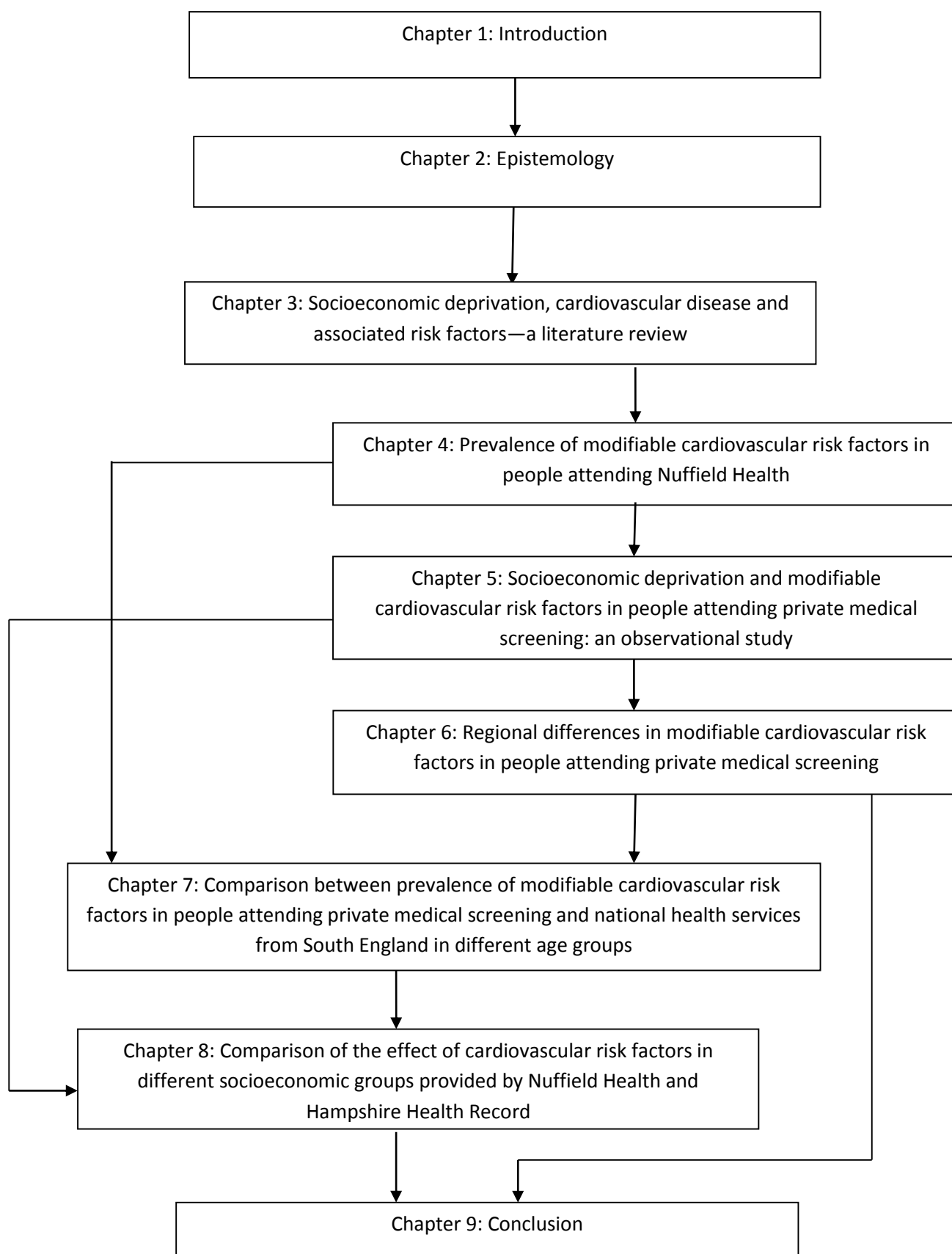


Figure 1.1: Outline of thesis

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CHAPTER 2:

EPISTEMOLOGY

2.1 PRIMARY AND SECONDARY DATA

Primary research entails the use of original *primary* data collected by the researcher. The popular ways to collect primary data consist of surveys, interviews and focus groups, which shows that direct relationship between the researchers and the researched. Secondary research involves the summary, collation or synthesis of existing data or research findings, and is a means to reprocess and reuse information previously collected for another purpose..

While primary research is a powerful method for acquiring information, it does pose several significant problems including high cost, time consuming, and it is not always feasible. Secondary data are useful for health research. Secondary data analysis can answer important questions and maximise opportunities provided by datasets through re-defining the way they are used. In health research, secondary data analysis is a legitimate approach to guide scientific inquiry and knowledge development. It can provide practical experience in data analysis, interpretation, and dissemination of findings. However, in secondary data, information relates to a past period and purpose, it lacks aptness and therefore, is not straightforward to use. . Secondary data analysis is conducted within an existing data set to answer research questions not posed in the original, or primary, study or purpose for collecting the data. Because many studies contain more data than the principal investigators can analyse, a variety of research projects can be conducted using pre-existing data (Kiecolt & Nathan, 1985).

Although secondary data are old, it may be the only possible source on the subjects, where primary data are not available. The advantage of secondary data analysis is its potential for resource savings and cost-effectiveness. The database often took months or even longer to collect. Human resources are limited, and adequate computer storage and memory are needed (Mainous and Hueston 1997). Descriptive studies allow investigators to access datasets from large samples when representative samples are difficult to obtain directly. This type of study is helpful in the research design of subsequent primary research and can provide a baseline with which the collected primary data results can be compared . It also provides essential

groundwork for further studies seeking explanation, prediction, and control of health research phenomena, and might be useful for investigating health service utilisation and clinical outcome or effectiveness of treatment over time (Burns and Groves 2001; Hearst *et al.* 2001; Rew *et al.* 2000). Hypothesis revision, or existing measures that need to be refined and improved, could use secondary data analysis (Hyman 1972; Nicoll and Beyea 1999). It could serve as a pilot study with aims to define a research question more clearly. This pilot study could lead to hypotheses generation for a subsequent primary study (Mainous and Hueston 1997; Nicoll and Beyea 1999).

Secondary data analysis is not a casual approach to data analysis that requires less scientific rigour. A legitimate study using secondary data analysis requires a sound conceptualisation of the research question to be studied, including a theoretical or conceptual framework. The framework serves to define how the concepts are performed and how the research questions are described. Although actual data collection with secondary data analysis requires less time than primary data collection, identifying and obtaining appropriate data for the study could be time-consuming. . Before the actual analysis, some effort must be made to determine the reputation of the original investigators and any limitations inherent in the original database or study, and analyse the overall quality of the data (Nicoll and Beyea 1999). Secondary data analysis must be coded or compiled in a way that individual participants cannot be identified, as well as confidentiality must be maintained. If confidentiality could be ensured and the new questions are in agreement with the aims of the original study, or researchable through the database it is not necessary to contact the participants from the original sample again for consent (Rew *et al.* 2000).

2.2. SOURCES OF DATASETS

Secondary data analyses in the clinical settings exist in patient charts, surveys, quality improvement and administrative management systems (Nicoll and Beyea 1999). Survey research obtains data from persons about particular topics, including demographics and behavioral, attitudinal, and social responses. Representative surveys sponsored by state and national governments, as well as surveys conducted by large universities, are examples of aggregate data sets that may be available for secondary data analysis (Rew *et al.* 2000).

Data in computerised databases are usually organised as individual or aggregate datasets (Hearst *et al.* 2001). The choice of dataset for the secondary data analysis depends on the research questions. Aggregate datasets contain information by groups or cohorts of participants.

Analyses using aggregate data are referred to as ecologic studies. Ecologic studies enable the investigator to analyse associations between the cohorts (Hearst *et al.* 2001). Large datasets are available from a wide variety of institutions and organisations in the UK, not only in public NHS hospitals and general practitioner clinics, but also in private medical insurance companies. Two large datasets used for my PhD thesis are from Nuffield Health and Hampshire Health Record.

2.2.1. Nuffield Health dataset

Nuffield Health is a private health-care company. Data were extracted from the records of the Nuffield Health. Aggregate data provided by the Nuffield Health were anonymised. Identification of individuals is not possible from these data, because they are provided by a unique patient reference number in a dataset. The assessment programmes were delivered through a bespoke electronic patient-record system developed exclusively for Nuffield Health, the Vi System. This system offers greater accuracy and speedier and more comprehensive reports than other systems (e.g. paper-based systems). It has four interventions—Vi₃, Vi₄, Vi₅, and Vi₆, and details are provided below.

Vi₃, female-only assessment (1 hour). This assessment was designed to aid a proactive approach for women's health and wellbeing. A tailored range of tests (height and weight measurement; body-mass index [BMI]; urine analysis; cholesterol; blood pressure; breast examination; pelvic examination and cervical smear; thyroid stimulating hormone blood test [for women aged 50 years and over]; high vaginal swab; and mammography [for those aged 40 years and over]) gives a clear, in-depth picture of a woman's current state of health. Participating women also have time with an experienced doctor to discuss personal and health concerns.

V_{i4}, lifestyle health assessment for both men and women (1 hour). This assessment (medical history and lifestyle questionnaire; height and weight measurement; BMI; body fat percentage; waist-to-hip ratio [WHR]; urine analysis; blood glucose and cholesterol; blood pressure; hydration level; analysis of general nutritional status; computerised spinal assessment; stress levels; and fitness assessment) looks at how lifestyle might be affecting participants' wellbeing and helps participants to find ways to make positive changes to their health and lifestyle. Highly trained health and wellbeing physiologists evaluate participants' health status and provide tools for sustainable change. A coaching session by a trained physiologist to motivate behavioural change is included in the programme. V_{i4}M is for men and V_{i4}F is for women. V_{i4}M + GP and V_{i4}F + GP include additional general practitioner consultation for men and women, respectively.

V_{i5}, so-called 360-degree health assessment for both men and women (2 hours). This assessment (full medical history and lifestyle questionnaire; height and weight measurement; BMI; body fat percentage; WHR; urine analysis; blood glucose and cholesterol; blood pressure; hydration level; analysis of general nutritional status; vision tests; lung function test; resting electrocardiography [ECG]; cardiovascular risk score; chest x-ray; bowel cancer test [for participants aged 50 years and over]; computerised spinal assessment; stress levels; and fitness assessment) includes access to the full range of the latest health evaluation technology. Participants have up to an hour with an experienced doctor to talk through concerns and health issues in detail, working out a management plan to improve health and meet lifestyle challenges. V_{i5}M is for men and V_{i5}F is for women.

V_{i6}, so-called 360+ health assessment for both men and women (2 hours and 45 min). With access to the full range of the very latest health evaluation technology and ample time with an experienced health professional, this assessment (full medical history and lifestyle questionnaire; height and weight measurement; BMI; body fat percentage; WHR; urine analysis; blood glucose and cholesterol; blood pressure; hydration level; analysis of general nutritional status; dynamic cardiovascular assessment [both at rest and during exercise]; vision tests; lung function test; resting ECG; cardiovascular risk score; chest x-ray; bowel cancer [for participants aged 50 years and over]; computerised spinal assessment; stress levels; and fitness assessment) investigates participants' health at every level. Participants have access to a dynamic test including ECG and measurement of blood pressure during activity and a

consultation with a physiologist to work out a plan to manage their health and lifestyle for optimum wellbeing and vitality. V_{i6M} is for men and V_{i6F} is for women.

It provides instant comparison with previous test results and the ability for clients to use any of the Nuffield centres in the UK and immediately to access their records. At each of the company's testing sites, data were collected by trained health professionals using protocols consistent with the British Hypertension Society (for blood pressure and blood analysis) and American College of Sports Medicine (for anthropometry). Protocol in assessing these measurements could be found in Appendix 2.1.

To ensure patients are getting the best possible outcomes from their treatment and care, Nuffield Health collected patients' health information during treatment and services through a network of over 200 facilities—private hospitals, health clinics, fitness and wellbeing centres, diagnostic units and a wide range of treatments into one complete healthcare service—across the UK.

Data quality has been defined by dimensions or characteristics including accuracy, availability, completeness, relevance, reliability, timeliness and validity (Dancey *et al.* 2012). Nuffield Health embedded these criteria in all the stages of patients' visits to improve the quality of data. However, Nuffield Health does have a relative fast staff turnover, but they are confident that the way data are collected—in-house training, adherence to protocols—are consistent no matter who collected the data or when the data were collected. Inter-rater reliability has also been performed to ensure the results are reliable or consistent in data collection. For example, when performing finger prick assessment for cholesterol level (in Appendix 2.1), test protocol are very detailed to instruct healthcare professionals in Nuffield Health to collect the blood for data record and further analysis, e.g. step 11—once strip is ready and client is ok switch on the machine and make sure the codes displayed match the strips will be using. If not, use supplied bar-coded strips within cholesterol pack and follow manufactures instructions to update code. Staff have opportunities to discuss why they chose the specific values they did. If there is any disagreement, they should discuss them and attempt to come up with rules for making decision. When collecting patients' data, the standards of confidentiality will be applied in accordance with data protection law and confidentiality. Anonymous or aggregated data are provided by Nuffield Health for my research.

Using dataset provided by Nuffield Health, two chapters in this thesis will analyse cardiovascular health outcomes for participants registered in the private medical insurance company. Chapter 4 aims to examine the prevalence of the different modifiable cardiovascular risk factors in the affluent population, and compares them to the general population represented in Health Survey for England 2006. Chapter 5 is the first retrospective cross-sectional study to examine the effect of area-level socioeconomic status on cardiovascular risk factors in people attending private health screening. Chapter 6 further explore geographical variation in the prevalence of modifiable cardiovascular risk factors in people attending private health screenings in England; it compares the prevalence of modifiable cardiovascular risk factors from private medical screenings with the findings from the HSE 2006; and estimates the risks of many modifiable cardiovascular risk factors at a regional level from dataset provided by the Nuffield Health.

2.2.2. Dataset from Hampshire Health Record

The Hampshire Health Record (HHR) is a joint project supported by Basingstoke and North Hampshire Foundation Trust, Hampshire Primary Care Trust, Portsmouth City Teaching Primary Care Trust, Portsmouth Hospitals NHS Trust, Southampton City Primary Care Trust, Southampton University Hospitals NHS Trust, and Winchester and Eastleigh Hospital NHS Trust. HHR provides a detailed record of care which contains most of the information held in the GP's record. It is stored by using a coding scheme (called READ Codes), which enables the data to be easily processed and displayed, whilst ensuring the quality and accuracy of the data is of a suitable level. Using this coding system means that only clinical data is shared and any comments GP may record for their own use are not shared. The amount of information will vary between patients, but will normally include information about allergies, medication, diagnosis, tests, and treatments.

Hampshire Health Record is part of the National Health Services (NHS). Data collection from HHR will comply with the clinical guideline, *Guide to Ensuring Data Quality in Clinical Audits*, published by UK Healthcare Quality Improvement Partnership in 2011. In the following chapters, Chapter 7 aims to compare the prevalence of various modifiable cardiovascular risk factors between Nuffield Health (private health screening) and Hampshire

Health Record (public NHS data), and to identify the similarities and differences of the two datasets in relation to the cardiovascular risk factors. Chapter 8 aims to examine the association between area-level socioeconomic status and objectively measured, modifiable cardiovascular risk factors in a population from an affluent region in England who attended the public NHS, and to compare the effect of socioeconomic status on cardiovascular risk factors between people attending Nuffield Health and Hampshire Health Record.

2.3. DATA SCREENING AND CLEANING

Before proceeding to the data analysis, datasets from Nuffield Health and Hampshire Record are screened and cleaned carefully. This is helpful in dealing with errors and missing data. In addition to a manual inspection of the data or data samples, using the *Descriptive, Explore, or Frequencies* options in Statistical Package for the Social Sciences (SPSS) software could be very helpful in helping to spot unusual patterns of data properties and detect data quality problems. There are many available strategies for problems involved in dealing with the very important topic of missing data, for example, listwise deletion, pairwise deletion, etc. How to deal with missing data depends on the reasons why the data were missing, and different missing data techniques could be applied. Null items within the datasets were coded missing. Outliers also exist in two datasets, they are more extreme than the rest of the values. For example, in the dataset provided by Nuffield Health, there are values such as systolic blood pressure > 300 mm Hg, but systolic >200 mm Hg, diastolic >130 mm Hg is a syndrome characterised by severe hypertension [Malignant (accelerated) hypertension]. It is not always appropriate to delete a value just because it is extreme. It is worth checking whether the outlier differed from the others on other measures as well. If the outlier is different in other ways too, then it might worth considering excluding this value from the analysis.

2.4. EPIDEMIOLOGICAL CONCEPTS USED IN THE THESIS

Epidemiology represents a method of studying a health problem and can be applied to a wide range of problems, from transmission of an infectious disease agent to the design of a new strategy for healthcare delivery.

Maxcy, one of the pioneer epidemiologists of the past century, defined epidemiology as below:

Epidemiology is that field of medical science which is concerned with the relationship of various factors and conditions which determine the frequencies and distributions of infectious process, a disease, or a physiologic state in a human community (Lilienfeld 1978).

John Last, in the Dictionary of Epidemiology, has defined epidemiology as follows:

The study of the distribution and determinants of health-related states or events in specified population, and the application of this study to the control of health problems.

Specific epidemiological study designs are used to achieve specific public health goals. These goals range from identifying a suspected exposure-disease relationship to establishing that relationship, to designing an intervention to prevent it, and finally, to assessing the effectiveness of that intervention.

In my PhD thesis, the studies mainly used retrospective design. Distinct advantages of such design are better for analysing multiple outcomes and helpful in addressing diseases of low incidence. However, significant biases may affect the selection of controls. There are some similarities between two datasets, for example, both datasets are collected at population-level, and populations are relatively affluent, data collection are through healthcare professionals, both datasets have large sample size, and data quality are up to optimum use, but differences also exist, for instance, the geographical distribution of the practices participating in Nuffield Health is across the UK population, apart from small variations between regions. HHR data are collected from south central England region only. Dataset provided by Nuffield Health collected a broad range of data covering key health concerns such as diabetes, heart health, cancer risk and emotional wellbeing (Appendix 2.2). and the dataset they provided for my PhD project included information about nine cardiovascular risk factors—BMI, waist circumference, waist-to-hip ratio, systolic and diastolic blood pressure, total cholesterol, LDL, HDL, and smoking. This will be the first opportunity to assess the effect of socioeconomic status (by postcode) on a cluster of cardiovascular risk factors in a large affluent UK population. In HHR dataset, seven cardiovascular risk factors were provided—BMI, waist circumference, systolic and diastolic blood pressure, total cholesterol, LDL, and HDL. Socioeconomic groups have been provided too in this dataset. However, postcodes were not provided. A number of

other variables would be welcome, such as smoking habit, weight, height, life style (diet, exercise). With retrospective studies, the temporal relationship is frequently difficult to assess. Retrospective studies also need very large sample sizes for health outcomes.

Epidemiological methods are used throughout the thesis. The statistical concepts that are relevant to the following chapters are discussed below. They lay the foundation for information that is needed to understand the series of studies. Hypothesis-testing paradigm started to use from Chapter 4, which aims to examine the prevalence of the different modifiable cardiovascular risk factors in the affluent population, and compares them to the general population represented in Health Survey for England 2006. The definition is introduced below.

2.4.1. Hypothesis-testing paradigm

According to Ajetunmobi (2002), a statistical hypothesis test is a method of statistical inference using data from a scientific study. In statistics, a result is called statistically significant if it has been predicted as unlikely to have occurred by chance alone, according to a pre-determined threshold probability, the significance level.

Null hypothesis (H_0): A simple hypothesis associated with a contradiction to a theory one would like to prove.

Alternative hypothesis (H_1): A hypothesis (often composite) associated with a theory one would like to prove.

Type 1 error: Reject H_0 when it is true

- Significance level (α) or Type 1 error rate: is the probability of making this type of error.
- This value is usually set to 0.05 for random reasons

Type 2 error: Failing to reject H_0 when it is false.

- The value β is the probability of a type 2 error or type 2 error rate.

Power: $1 - \beta$ probability of correctly rejecting H_0 when it is false

Below, the discussion will be around the reasons why use effect size and analysis of variance (ANOVA), and odds ratio and logistic regression in the following chapters (Chapters 5, 6 and 8), difference between statistical significance and clinical importance, as well as the introduction of regression and its application in my PhD chapters.

2.4.2 Effect size and ANOVA

In statistics, an effect size is a quantitative measure of the strength of a phenomenon. Reporting effect sizes is considered good practice when presenting empirical research findings in many fields. The reporting of effect sizes facilitates the interpretation of the substantive, as opposed to the statistical, significance of a research result. Effect sizes are particularly prominent in social and medical research. Relative and absolute measures of effect size convey different information, and can be used complementarily.

Analysis of variance (ANOVA) is a method of significance testing based on the ratio of between groups variance to within-groups variance. This method is used in statistical analysis if the dependent variable is continuous and the independent variable or variables are all categorical (i.e. nominal, dichotomous, or ordinal). If there is only one independent variable, the method is called one-way ANOVA. If there is more than one independent variable, the method is called *N*-way ANOVA, with *N* representing the number of independent variables.

2.4.3. Odds ratio and logistic regression

An odds ratio (OR) is a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. Odds ratios are most commonly used in case-control studies, however they can also be used in cross-sectional and cohort study designs as well (with some modifications and/or assumptions).

Odds ratios are used to compare the relative odds of the occurrence of the outcome of interest (e.g. disease or disorder), given exposure to the variable of interest (e.g. health characteristic, aspect of medical history). The odds ratio can also be used to determine whether a particular

exposure is a risk factor for a particular outcome, and to compare the magnitude of various risk factors for that outcome.

- OR=1 Exposure does not affect odds of outcome
- OR>1 Exposure associated with higher odds of outcome
- OR<1 Exposure associated with lower odds of outcome

Confidence interval (CI) is an interval within which the population parameter (the true value) is expected to lie with a given degree of certainty (e.g. 95%). The 95% CI is used to estimate the precision of the OR. A large CI indicates a low level of precision of the OR, whereas a small CI indicates a higher precision of the OR. It is important to note however, that unlike the p value, the 95% CI does not report a measure's statistical significance. In practice, the 95% CI is often used as a proxy for the presence of statistical significance if it does not overlap the null value (e.g. OR=1). Nevertheless, it would be inappropriate to interpret an OR with 95% CI that spans the null value as indicating evidence for lack of association between the exposure and outcome.

When a logistic regression is calculated, the regression coefficient (b_1) is the estimated increase in the log odds of the *outcome per unit increase* in the value of the *exposure*. In other words, the exponential function of the regression coefficient (e^{b_1}) is the odds ratio associated with a one-unit increase in the exposure.

Statistically significant effect is an outcome for which the difference between the intervention and control groups is statistically significant (i.e. the P value is ≤ 0.05). A statistically significant effect is not necessarily clinically important. Statistical significance is used in hypothesis testing, whereby the null hypothesis (that there is no relationship between variables) is tested. Statistical significance relates only to the likelihood that results obtained were not due to chance. Clinical significance answers the question, *how effective* is the intervention or treatment, or how much change does the treatment cause? In terms of testing clinical treatments, practical significance optimally yields quantified information about the importance of a finding.

2.4.3.1. Linear regression vs Binary logistic regression

Binary logistic regression estimate the probability that a characteristic is present (e.g. estimate probability of ‘success’) given the values of explanatory variables, in this case a single categorical variable. Linear regression measures the relationship between a categorical dependent variable and one or more independent variables.

Logistic regression is used to refer specifically to the problem in which the dependent variable is binary. For example, the number of available categories is two; and while problems with more than two categories that are referred to as multinomial logistic regression.

2.4.3.2 Continuous variables vs ordinal grouping vs categorical variables

Continuous variables are described as data that can take any value within a given range. For example, body weight, temperature, head circumference, etc.

Ordinal variables are similar to continuous variables; they can be ordered sequentially. They are also similar to categorical variables because they (perhaps) cannot be differentiated from each other using a mathematical method.

2.4.4. Chi-square test

Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis. Chi-squared tests for variance are used to determine whether a normal population has a specified variance. The null hypothesis is that it does. This test is used in Chapters 4 and 7.

2.5. CONCLUSION

Database research has many advantages—it is believed to be fast and not as expensive as experimental or other prospective studies, and it can analyse very large masses of data. It might be able to detect unexpected phenomena or demonstrate differences among subgroups that might not be included in a controlled experimental study. When it is not statistically definitive it can help refine questions, generate hypotheses, identify potential recruits for experimental studies, complement experimental studies, and generally inform the design of other research. And often it can proceed without the participants having to be involved or affected, especially if it uses anonymised data.

Data quality is one of the common issues to ensure the robustness of secondary research. Data quality is important because accurate and timely information are needed to manage health services and improve quality of patient care; provide good information to manage health service effectiveness; prioritise and locate the health resources; and make judgements about the performance and governance in the organisation. Obtaining good-quality data is only a starting point, ultimately achieving data quality should be able to help to ensure that high-quality evidence is used to guide the allocation of health-care resources efficiently and improve the patient care.

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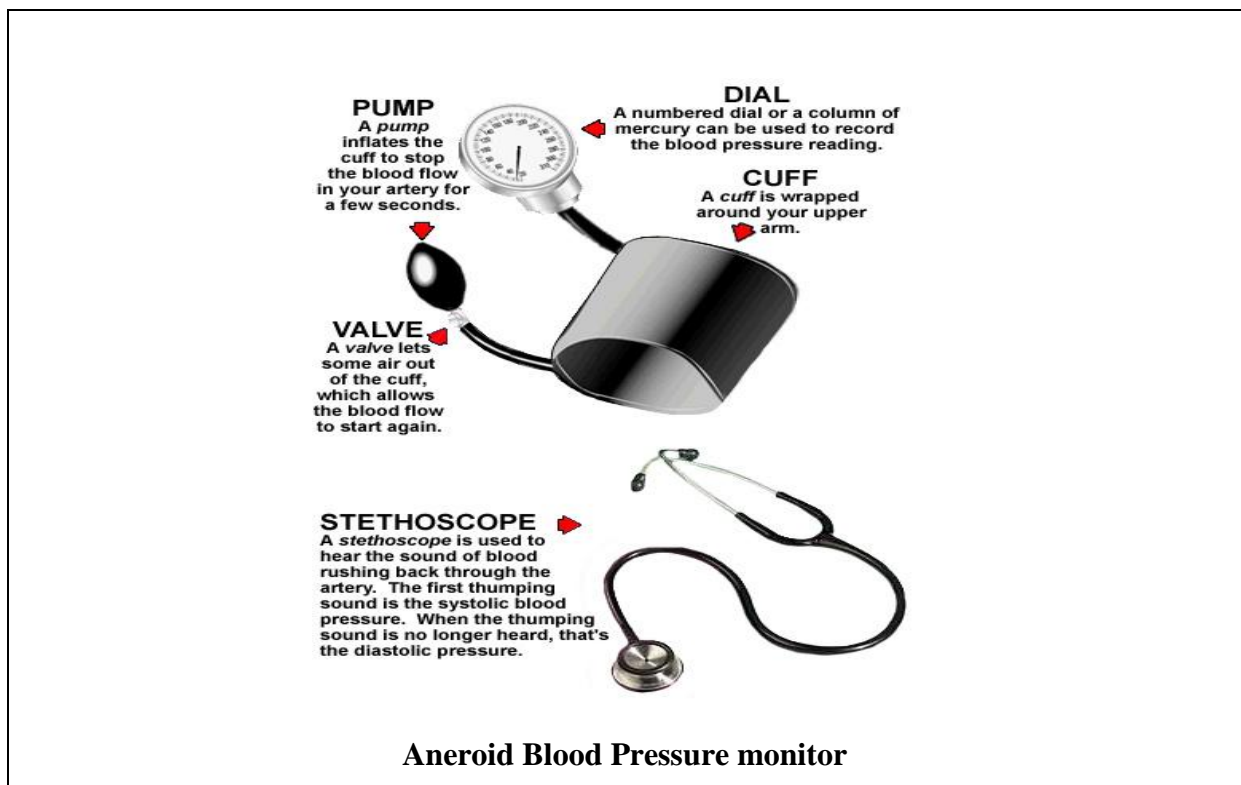
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APPENDIX 2.1

Processes for tests included in data extract

Blood pressure

Master Skills



5.1 Prior to appointment

The client should be as relaxed as possible.

A full bladder *may* affect the blood pressure so the client should have been offered the opportunity to empty his/her bladder prior to this. (Ideally for urinalysis).

No Caffeine for 4 hours prior to measurement.

No Nicotine for 30 min prior to measurement.

Identify arm used for venepuncture and use the **other one** for measurement.

5.2 Test Protocol using an Aneroid Manual Blood Pressure monitor

1. Explain to the client that blood pressure is to be taken and discuss the procedure. Allow the client to rest for three to five minutes. Legs should not be crossed
2. Select the appropriately sized cuff for the client's arm. The cuff should cover 80% of the circumference of the arm.
3. Remove any restrictive clothing
4. Ensure that the upper arm is supported and positioned with the mid point at heart level and with the palm of the hand facing upwards
5. Apply the cuff of the sphygmomanometer snugly to the upper arm with the lower edge of the cuff approximately 2cm above the antecubital fossa ensuring that the centre of the bladder covers the brachial artery
6. Palpate the brachial pulse and inflate the cuff until the pulse can no longer be felt and then increase the inflation by 20mmHg
7. Deflate the cuff and note the level at which the pulse reappears – this is the approximate systolic pressure
8. Deflate the cuff completely and wait for 15 – 30 seconds
9. Re-inflate the cuff to 20 mmHg above the point at which the pulse disappears
10. Place the bell of the stethoscope over the brachial artery. It should not be placed over clothing
11. Slowly deflate the cuff at 2-3 mmHg per second, listening for Phase one Korotkoff sounds
12. Note the systolic pressure when phase one is heard

13. Continue to deflate as above until no sounds are heard. Note the diastolic pressure when all sounds disappear completely. (Be aware of the possibility of an auscultatory gap).

14. The cuff should be deflated slowly for another 10mmHg to ensure that no further sounds are audible and then rapidly and completely deflated.

5.3 Precautionary measures

Do not apply more pressure with the stethoscope than necessary as this may distort the reading.

Do not tuck the bell of the stethoscope under the cuff – this could exert additional pressure on the brachial artery.

Do not allow the client to talk during the measurement.

Korotkoff's Sounds

In 1904, Nicolai Korotkoff discovered that by using a stethoscope below the cuff over the artery at the elbow, characteristic sounds could be heard at systolic and diastolic pressure.

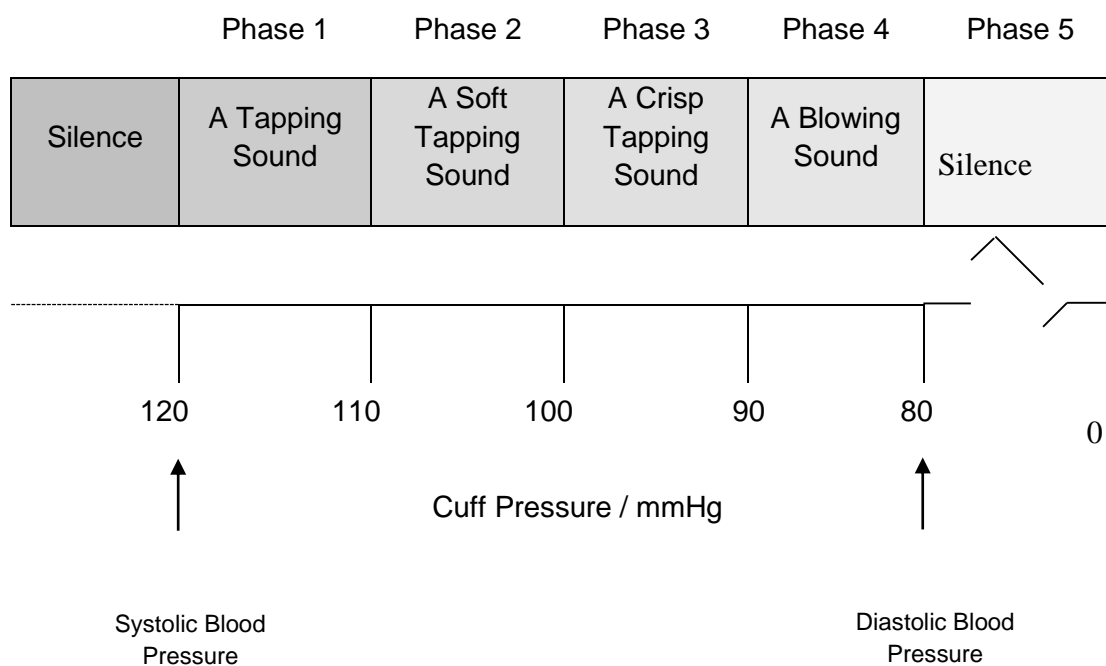
'Korotkoff's Sounds'

Phase one	the appearance of faint, repetitive tapping sounds gradually increasing in intensity and lasting for at least two consecutive beats.
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Phase two	A brief period where the sounds soften or swish.
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Auscultatory gap	in some clients the sound may disappear altogether.
Phase three	the return of sharper sounds becoming crisper but not with the intensity of phase one.
Phase four	the distinct abrupt muffling sounds becoming soft and blowing in quality
Phase five	the point at which all sounds disappear.

Korotkoff Noises



Record Phase one as Systolic

Record Phase five as Diastolic

Cholesterol

Master skills – Finger prick assessment

4.1 Prior to appointment

Client should be fasted ideally for a period of two hours prior to the assessment. A non-fasted test is still worthwhile performing although may need a re-test if it is above the recommended range. Fasting further helps ensure reproducibility.

Dilution of capillary blood by tissue fluid can contribute to an inaccurate finger-prick result when compared against a venous sample. This should be explained to the client.

Damage to blood cells from this method of collection can sometimes cause inaccurate test results (and the need to repeat the test with blood drawn from a vein). This should be explained to the client.

Finally explain to the client the test is a gauge of total cholesterol and not cholesterol breakdown. Due to the increasingly important role of HDL cholesterol and heart risk we will not get the full picture from this test although it is an excellent marker of what the lipids levels are like within the bloodstream.

Blood Safety

Take care when dealing with blood and needles.

When dealing with blood always ensure:

- The physiologist works in a safe and clean manner.
- That disposable gloves are worn by the physiologist whenever the physiologist may come into contact with blood performing the test.

- A sterile and clean working area is maintained for performing the test.
- Any blood spillages are cleaned up immediately using alcohol wipes.
- Needles are disposed of immediately and safely into a clinical sharps bin.
- All consumables are disposed of in appropriate sanitary waste.

In the unlikely event of you pricking yourself with a used needle / lancet, it is important that you understand the company policy and explain the procedure to the client involved.

- 1) Thoroughly wash wound immediately and promote bleeding by opening the wound and squeezing.
- 2) First contact Oli Patrick Professional Head of Physiology, as soon as possible. Oli Patrick will be able to remind you of the company blood safety procedure and ensure appropriate measures for your safety are undertaken.
- 3) You will also need to explain to the client that is our company policy that they will require a blood test for HIV and Hepatitis B. This test will be organised for them.
- 4) You will also require the same blood tests

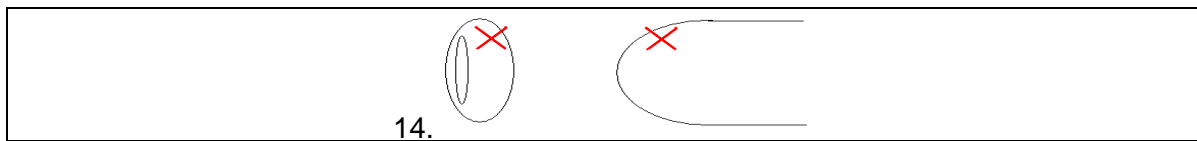
BE SAFE WITH NEEDLES – DISPOSE OF THEM WITH SAFETY AND CARE

4.2 Test protocol

TEST PROTOCOL

1. Make sure you have a clean and sterile surface to perform the test. A clinical sharps bin should be placed within easy reach onto the table.

2. Check client has fasted for 4 hours and only had a light breakfast/lunch prior to that. If client has not fasted explain results cannot be taken as valid although they may provide a useful biochemistry marker (see validity of results).
3. Reassure client about what test you are about to perform and you must ask their permission to prick their finger with a finger prick device to attain 2 drops of their blood for Blood Cholesterol analysis.
4. Seat the client next to a table and ask them to remove any item of clothing that may be making them uncomfortable.
5. Load the Soft click finger prick device with a new lancet in front of the client (as per instructions on device) and explain to the client that a clean lancet / needle is being used. Set the appropriate depth of the device (For most adults this will be #3, however, a lower number may be more appropriate for children or slim clients).
6. Remove one cholesterol strip (of the same codes) from air-tight sealed pots and replace lids afterwards.
7. Place the strips next to the Blood Cholesterol Monitor on the sterile surface.
8. Sitting next to the client and wearing rubber gloves ask the client to present you with a finger. It is usually recommended to use the second finger but clients may prefer to use another finger.
9. Clean the end of the selected finger with an alcohol wipe and allow drying. Place some cotton wool to one side of the sterile surface.
10. Gently palpate the finger in a milking fashion with the aim of drawing blood towards the tip of the finger.
11. Once strip is ready and client is ok switch on the machine and make sure the codes displayed match the strips you will be using. If not, use supplied bar-coded strips within cholesterol pack and follow manufactures instructions to update code.
12. Take the unused Cholesterol strip and slide it through the front of the machine. Wait for the beep to signal the machine is ready then open the top flap. The screen will display the test time (180 seconds for cholesterol, 12 seconds for glucose). The machine is now ready to analyze.
13. With the clients palm facing upwards. Place the centre of the loaded finger prick device next to the most distal portion of the client's finger, off the main finger pad and slightly to the side (See diagram below).



15. Warn the client of the imminent small sharp pain and reassure if required. Then click the release button.
16. Dispose of the lancet into the clinical sharps bin as soon as you have done this.
17. Ask the client how they are feeling at this time and check for signs of dizziness or fainting.
18. Gently palpate the finger in a milking fashion again pushing blood towards the end of the finger. If no blood arrives continue to do this for a few seconds whilst gently opening up the small wound with thumbs. You can also ask the client to lower their hand to increase the pressure in the region.
19. Wipe away the first drop of blood with the cotton wool and place immediately in the clinical waste bin. Begin to milk the finger again to gain a fresh sample.
20. Once you have got a drop of blood about the 2-3mm in size, place the testing strip close to the blood. It should be gently absorbed into the pad on the stick. **Only apply blood outside of the meter.**
21. **Take care not to press the pad of the stick directly onto to the skin** so to avoid any moisture/skin cells from skin passing onto testing strip.
22. Continue this process until you have enough blood on one strip. The underside of the strip has a circle that will change colour (red) to indicate enough blood has been collected.
23. Throughout this process be very sensitive to the client and if they are in too much pain or are feeling unwell be ready to stop at any time.
24. Give the client the small ball of cotton wool and ask them to push down on the small wound with the cotton wool. After a few minutes if the wound has not healed offer a plaster. The client should not suck their finger as this will prolong the bleeding.
25. After the allotted time the machine will beep to indicate the result is ready. Record this result immediately (results are cleared from screen after a few seconds).

26. Switch off the machine, dispose of all consumables into a sharps bin or clinical waste bin and clean machine internally with an alcohol wipe (70% alcohol). Prior to next client clean machine as detailed below.
27. Warn client you will require another finger for the glucose test. You will also have to use a new lancet.
28. Follow the same procedure for blood glucose.

Body fat/Body water

Master skills



2.1 Prior to appointment

Ideally: No food or drink, excluding water, 4 hours prior, complete evacuation of bowel, empty bladder, maximum 30 minutes prior to the test, no heavy exercise 12 hours prior, no alcohol 48 hours prior.

Realistic: well hydrated and no diuretics prior to test (unless prescribed by a doctor).

Low Hydration levels do affect the accuracy of the result and clients should be reminded to attend well hydrated.

Important Note:

Do not perform on those with pacemakers or with any implantable electronic device.

Why?

The affect of the single frequency Body Stat 1500 unit could cause interference with operation of electronic medical devices.

Do not perform on pregnant ladies

Why?

The effects of an electrical current on a foetus are not known.

Women experience more changes in hydration levels than men because of their menstrual cycle and this can affect body fat measuring, particularly using the BIA method. Retaining fluid may also cause weight to fluctuate day-to-day during this period causing additional variation in the body fat percentage

2.2 Test Protocol

- Explain Bioelectrical Impedance Analysis (BIA) to the client

Based on the two-compartment method of body composition: – Fat component and Fat-Free component (lean), BIA is a rapid and non-invasive method of measuring body fat.

Bioelectrical Impedance Analysis (BIA) measures the impedance or resistance to the flow of an electric current through the body.

Impedance is low in lean tissue, due to intracellular and extracellular fluid.

Impedance is high in fat tissue.

Impedance is also proportional to the total body water volume.

Bio-Impedance Analysis has been correlated most frequently with hydrostatic weighing.

1. Ask client to remove both their right shoe and right sock and lie down on the couch
2. Place the proximal sensor on the dorsal surface of the wrist so the upper border of the electrode is placed against the most distal part of the ulna.
3. Place the distal sensor at the base of the second or third metacarpal-phalangeal joint of the hand
4. Place the proximal sensor on the dorsal surface of the ankle so that the lateral border of the electrode is placed against the medial part of the lateral malleolus
5. Place the distal sensor at the base of the second or third metacarpal-phalangeal joint of the foot
6. Attach the red electrode to the distal sensor and the black to the proximal on both hand and foot
7. Make sure the client's arms and legs are abducted at approximately 45 degrees of each other. There should be no contact between legs or between arms and body
- 8. Double check for any contraindications to perform the test**
9. Explain this test will not cause any sensation. and perform the test by sending the pulse.
10. Disconnect the client and remove the electrodes.
11. Inform the client of the results of their total body fat percentage. Abstain from a full explanation at this stage if you are performing an assessment that will allow you more time later when even more information is at hand to put the results into context.

Antioxidant score

Using Biophotonic scanner

Master skills

2.1 Procedures - Prior to the appointment

- 1) The scanner should be warmed up and calibrated – allow at least 50 minutes *prior to* the first client scan
 - a. Sufficient Scan Certificates available for all appointments booked
 - b. Sufficient calibration putty – calibration is done twice a day when prompted.
- 2) The questionnaire on lifestyle and nutrition should be completed by the client for better understanding of their habits and lifestyle

2.2 Test Protocol

- 1) Enter the first and last name fields as defined by Nuffield Proactive Health
 - a. 1st Name = Nuffield
 - b. Surname = Client ID
- 2) Enter the Nuffield Hospital Location post code
- 3) Tick box for NO EMAIL
- 4) Place the right hand on the scanner in the preferred position
If there is scarring or a physical handicap that will not allow the right hand to be scanned, use the left hand in the preferred position.
- 5) Begin the scanning process – 3 minutes until a result is revealed
- 6) Mark all demographic questions as ‘no answer’ – pull down menu option

- 7) Discuss client answers from the questionnaire in order to better understand the client lifestyle habits and risk factors associated with antioxidants/free radical sources
- a. Information Gathering – a flexible process
 - b. Briefly explain - The scanner and the scan
 - c. Brief explanation of what the scanner is doing
 - d. Manage any concerns about test – i.e., pregnant women is safe, Non-invasive, pain free
 - e. Explain Anti-oxidants and Free Radicals
 - f. The impact of lifestyle

Prepare to show score

- g. Explain, using the score sheet, what the results mean will mean
 - h. Ensure the client can see the laptop screen when revealing their score
 - i. Emphasise this is their baseline score, and is influenced by their genes, lifestyle, diet, supplementation and other factors
- 8) Press OK when prompted – this will reveal the individual's scanner score.
- 9) Explain the results
- 10) Discuss the recommendations – all facets of lifestyle change inclusive of supplementation.
- a. How to manage score expectations / reactions
 - i. No good or bad, it is their baseline
 - ii. Any score can be increased from whatever baseline
 - b. Go through positive and negative influences, using information gathered, and make recommendations
 - c. How to manage very low score
 - i. Which reflects lifestyle
 - ii. Which does not reflect lifestyle
 - iii.
- 11) Score Validation
- a. If score less than 20,000 rescan to ensure hand was not moved during scan if score < 10,000
 - i. Recommend serious increase in nutritional awareness (possible nutritionist)
 - ii. May be absorption issue
 - iii. May need more tests
 - b. If score < 20,000

- i. Does it reflect lifestyle?
- ii. Concern if significant difference between score and lifestyle
- iii. Big negative influences are smoking, overweight, stress and medication
- iv. If score much lower than expected – check nothing missed in dialogue
- v. If mismatch between score and lifestyle
- vi. Recommend serious increase in nutritional awareness (possible nutritionist)

12) Lifestyle and Diet Guidance

- a. Negative factors – free radical generators
 - i. Smoking
 - ii. Stress
 - iii. Over-weight
 - iv. Excessive exercise
 - v. Environment
- b. Positive factors – increase anti-oxidants
 - i. Type and quantity of fruit and vegetables
 - ii. Cooking method
 - iii. Fresh and organic
 - iv. Supplementation

13) Recommendations

- a. Objective – as high a score as possible
- b. Reality – corporate life, time pressures, lifestyle
- c. Recommendations
 - i. REALISTIC
 - ii. Based on
 - 1. Client attitude to health
 - 2. Their priorities
 - 3. Start with easy goals
 - 4. More portions, change type of vegetables, cooking method
 - 5. Importance of stress and weight management, smoking
- d. Recognise for most clients impossible to get optimum score without supplementation

14) Recommendation Process

- a. Common sense
- b. Address the concerns of the client
- c. Part of lifestyle change, not isolated or ignored or 'end in itself'
- d. Priority areas first
- e. Written 'prescription' of recommendation supplementation needs

SNS/PSNS

Master skills

Using Nerveexpress HRV technology.

Prior to appointment

Ensure limited caffeine and limited exercise for 4 hours.

Ideally client will not have eaten substantially for 2 hours prior to appointment

Test protocol

1. Debrief the client briefly regarding the purpose of the test and what we are hoping to achieve. Avoid using or referring to the word 'stress'.
2. Tell them that there will not be any talking throughout to ensure accurate results
3. Ensure the client does not move substantially during the test other than the standing up action.
4. Enter the client's name. DOB and ID number under additional information on the screen
5. Take the heart rate monitor and moisten the sensors with an alcohol swab
6. Assist the client with putting on the heart rate monitor – this should be approximately level with the sternum and underneath the client's shirt
7. Ask the client to lay down on the couch in the supine position and relax
8. Attach the nerve express clip onto the patient's shirt, ensuring that it is within 30 cm of the HR monitor
9. Click on 'New Test' and then 'Start'

10. When the words 'Client stand up' appear on the screen, ask the client to slowly stand and face the corner of the room, ensuring that the lead is still connected and a signal still being transmitted
11. After the selected number of heart beats, the test will be complete and the screen will change showing the graphical analysis of the test
12. Remove the lead and HR monitor from the client
13. Click on print – tick Nerve Express and Fitness Express icons only – then click 'Ok' to print off the RI result to talk through with the client in the consultation at the appropriate time

1.7 Key problem solving

Problem	Possible solution
No signal	Is the belt wet enough? If not then use another swab on the receiver pads and try again.
	Does client have inverted sternum? If so try to move belt so side 'pads' have as much contact with ribs as possible.
	Are all leads connected at back of console? If not re-connect and then try again.

Loss of signal half way through test	Has the receiver dropped off? If so there is a small window of opportunity <15 seconds to re-connect receiver and continue test. If no signal returns then apologies and re-start test. If it happens again then the test may have to be re-scheduled.
	Has the belt slipped when the client stood up? If so then ask the client to push the belt against their skin to provide a stronger signal. Tighten the belt if you have time. As above if not signal returns.
Client gets bored during test and starts to talk	Although this won't stop the test it will make it less reproducible and less valid. Try to encourage them to be still and if not possible then work with the results given.

SpinalMouse score

Master skills

Prior to appointment

Ensure clients are informed of the test protocol and that appropriate clothing is available to allow a test to take place.

If client has an existing back pain problem take note of this and only perform the **upright** measurement rather than the full spinal score

Test protocol

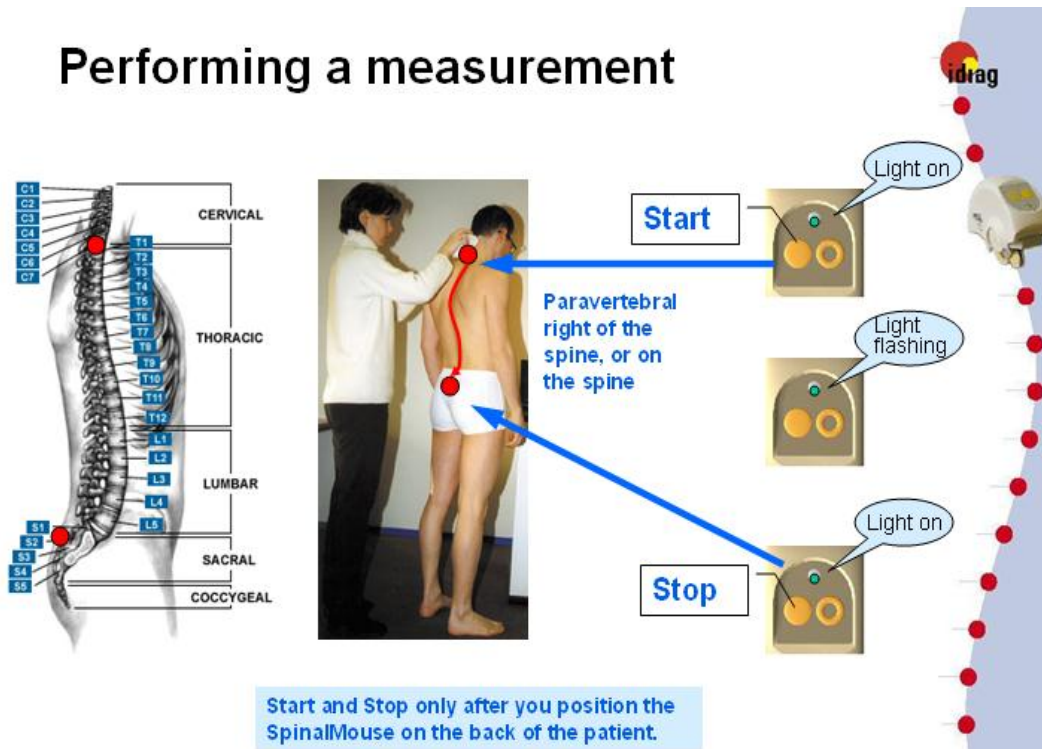
Open spinal mouse program through Vi system on computer

Ensure spinal mouse unit is 'on' within docking station

Follow protocol as displayed in the spinal mouse manual

Fig 4

Performing a measurement



Explain measurement process thoroughly to client explaining that to measure to S3 (aka Rima ani) effectively the mouse will have to roll into the top of the cleft of their buttocks. This process does not require taking pants off but will require exposure of this area.

If the client is uncomfortable with this process then they may retain their pants and a degree of error should be factored in regarding lumbar spine results.

Female clients should already be wearing the spinal mouse garment. At this point they should remove their bra and shoes. Men should remove shoes only.

Females – open the rear panel of the spinal mouse to ensure access to C7 and S3.

Males – request they remove their shirt and lower pants as appropriate against earlier discussion.

Remove the spinal mouse unit from the holder and hold in one hand. Press the right hand button to move select the upright test from the 3 options listed

Upright

Flexion

Matthias

Upright test

Ask the client to stand with feet at shoulder width apart

Arms should hand relaxed, laterally to the body

Weight should be evenly distributed

Focus should be horizontally – straight on

With the free hand identify C7 on the client

Tip...

To find C7 ask the client to bend forwards. C7 will be the most prominent. Place your finger on C7 and then ask the client to stand up straight again – it will disappear on standing in most cases

Once C7 is identified place the spinal mouse on the clients back with C71 **in-between** the two measuring discs on the mouse unit

Once the spinal mouse is in place press the left hand button to start the reading. The button need not be held down.

Roll the spinal mouse down the spinal processes slowly putting a light pressure to keep a good contact with the skin

The spinal mouse can take an accurate measure if it reads just to the side of the spinal processes so do not be concerned if the mouse moves slightly to the side during the measurement

Fig 5



Once the spinal mouse has reached S3 press the left hand button again to stop the reading. Ensure the result has been recorded on the computer program

If the technique of measurement was not satisfactory then repeat the process. If happy then use the right hand button to move to the flexion posture

Flexion

For flexion testing ask the client to bend forwards as far as is comfortable whilst keeping their knees locked and legs straight.

Arms should hang down by to their sides, relaxed

Fig 6



Once flexion measurement has been completed press the right hand button to move onto the Matthiass test

Fig 7

Loaded Test - Matthiass (postural competence)



MAKE POSTURES RELIABLE !

00:00



00:30



<u>Body weight</u>			Man	Woman
< 55 kg	=		2x 1,5 kg	2x 1,0 kg
56 to 70 kg	=		2x 2,0 kg	2x 1,5 kg
71 to 85 kg	=		2x 2,5 kg	2x 2,0 kg
> 86 kg	=		2x 3,0 kg	2x 2,5 kg

Weight information shown is only for healthy subjects. They do not apply/should not be used with back pain patients



Matthiass

Select the appropriate weight dumbbells based on the sex and weight of the client (see fig 7)

Remember – Matthiass is not for use in clients with existing back pain. In these cases a simple upright measure is enough

Ask the client to hold the dumbbells at a 90 degree angle to their body (shoulder height)

Begin the stopwatch. Note – there is a stopwatch function available on the Spinal mouse program

When the stopwatch reaches 20 seconds prepare to take the Matthias reading. The reading should be performed exactly as the upright protocol.

Begin the measurement exactly on 30 seconds and once measurement has ceased instruct the client to lower their arms and return the dumbbells

Allow the client to appropriately dress for the next test within their health assessment

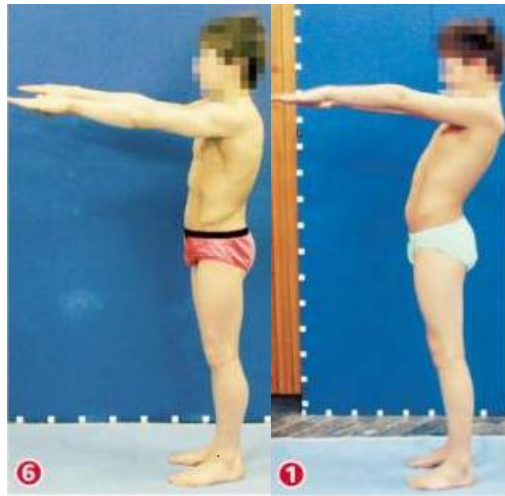
Matthiass master class

The Matthiass test is designed to identify postural weakness by comparison of two standing postures. The first posture is normal and the second is with both arms in the horizontal position holding an appropriate weight (based on sex and weight).

The patient is measured in the first position. Then, after 30 seconds with arms up, the measurement is repeated. Holding the arms horizontally moves the center of gravity forwards, and this stress is often compensated by shifting the whole body back. The pelvic girdle moves forwards and lordosis deepens.

Patients with weak back-musculature show large differences between the two measurements: Shoulders shift back, hips forwards and lordosis is increased as in figure 8 below

Fig 8



#6 : Good Posture, # 1: Weak Posture

References further investigating the logic of the Matthiass test are shown at the end of this chapter. Matthiass test is a gauge of postural skill and serves to identify risk of future problems - based on the role of muscular strength and endurance in preventing lower back pain.

Assumptions have always been made about importance of strength within both rectus abdominus and deeper abdominal muscles – most recently and notably transverses abdominus. Although significant volumes of studies have focused on the endurance ability of stabilising muscles rather than their dynamic power.

Various studies conducted through the 1980's (2, 3) repeatedly showed the muscular endurance capability of the erector spinae and other postural muscles had the largest influence on incidence of back pain – with increased endurance correlating to the lowest incidence of pain. Matthiass test is a combination of muscular strength and isometric endurance and as such offers vital insights into these proven areas. It also lends suggestion to the type of training that should be recommended to be both preventative and proactive in back care.

Lung function

Master skills

2.1 Prior to test

Ensure the machine is calibrated – see maintenance

The client should not have:

- Smoked for 24 hours
- Drunk alcohol for 4 hours
- Eaten substantially for 2 hours
- Exercised vigorously for the past 30 minutes
- Taken bronchodilators for 4 hours

None of the above are contraindications but a note should be made on the Vi system

Ensure the client does not have any contra-indications to taking the test

2.1.1 Contra-Indications to Spirometry

- Hypertension (B.P. exceeding 190/100)
- Haemoptysis – coughing up blood
- Pneumothorax – collapse lung tissue
- Unstable cardiovascular status, unstable angina or recent heart complaint
- Aneurysm – a local dilation / weakness in artery wall
- Recent eye surgery / detached retina
- Recently perforated ear drum
- Recent thoracic (chest) or abdominal (stomach) surgery
- Pregnancy – first three months or last three months
- Current acute back problems – seek advice if unsure

2.2 Test protocol

1. Switch on the Vitalograph machine
2. Enter the correct date and temperature (check thermometer on face of machine)
3. Enter accurate subject data, using the patient CIN number as the reference number
4. After the client demographics have been entered, the printer starts, confirming the client as current user.
5. Inform the client that you are inserting a new mouthpiece into the machine
6. Select FVC Test (Forced Exhalation Test) from the main menu
7. Give visual demonstration of correct technique
8. Commence FVC Test only when the READY prompt is displayed

Client Instructions for Performing the Test:

- Stand up
- Take hold of the unit, keeping it in a vertical position and away from your mouth
- Inhale as deeply as possible and insert the mouthpiece into your mouth, clamping it between your teeth
- Seal your lips fully round the mouthpiece
- Exhale as quickly as possible and try to keep exhaling for at least 6 seconds until the physiologist sees the FVC line obviously plateau

9. Encourage the client to keep exhaling as you monitor the exhalation volume
10. After the test, ask the client if they are ok. Ensure you have a seat nearby in case they feel light-headed immediately after performing the test

Minimum of 3 attempts and a maximum of 8 tests is recommended. Curves for each test will be displayed on the screen. The 'best' test (highest FVC + FEV1 sum) will be stored for output on the printed test report. It is imperative to monitor how the client is feeling and your judgement on correct technique in previous attempts, as to whether you request more than 3 tests.

11. Print out the report, which provides the client's data, test results and graph. To stop the printer, press the enter key during printing.
12. Insert the results for FVC, FEV1 & PEF into the ViSystem.

APPENDIX 2.2 Variables for extraction from the ViSystem

Variable/Parameter	Comment
Subject ID	
Postcode	
Age	
Gender	
Height	
Weight	
BMI	
Waist	
Hip	
Blood Pressure	
Cholesterol	May be part of biochemistry blood results
Bioimpedance	
Body Water	May be part of bioimpedance results, but valuable to have this field separately
Antioxidant score	
NBCIndex	Calculated using body composition data within the Vi4, Vi5 and Vi6
SNS/PSNS relationship	Mirroring the corporate report formula put together by Richard Brennan. The formula records a positive result based on DSNS ≤ 0 and SNS ≥ 0 and (DSNS < 1 or SNS > 1) All other results would be deemed negative
Subjective stress score	Taken from questionnaire page of Vi System – this will often be missing due to insufficient data entry.
Behaviour scores break down	Activity score (isolated) Exercise score (isolated) Nutrition score (isolated) Life balance score (isolated) Smoking score (isolated)
Smoking	Either/and/or Smoking score from behaviour page or selection of smoking from questionnaire page.
Alcohol units per week	From questionnaire page
Alcohol units how often	Number of day drinking per week
Spinal mouse score and breakdown of scores	Eg Total score, Upright score, flexion score and postural competence score (4 results taken from the spinal mouse page)
Fasting status	To compare against glucose and cholesterol interrogations. Taken from physical measurements page
Exercise, activity and relaxation section	Taken from Vi questionnaire including all options from motivation for exercise drop down box.
Sleep health	From Vi questionnaire
Psychological health	From Vi questionnaire

Corporate account details	From Samba? To allow reviews against sector.
Lung function (absolute and % values)	Results taken from physical measurements page
Exercise ECG report from cardiologist	Report received back from cardiologist team at Warwick. The code from the system will suffice.
Cardiovascular risk score	From the Framingham calculation within the clinical examination section of the health assessment.
VO2 max score x 2	From the data entry in physical measurement in Vi4 and from the calculation from heart rates in the Vi6
Biochemistry blood results	Eg. Uric acid, ALP, ALT, GGT, Calcium etc. The full range.

If possible (nice to have)

Haematology blood results	Eg FBC, WBC etc
Urinalysis results	All 8 parameters from physical measurements

CHAPTER 3:

SOCIOECONOMIC STATUS, CARDIOVASCULAR DISEASE, AND ASSOCIATED RISK FACTORS—A SYSTEMATIC REVIEW

Abstract

Globally, cardiovascular disease is the leading cause of death and is predicted to remain so. Understanding of the risks to health is the key to prevention of cardiovascular diseases and events. A cardiovascular event is often caused by more than one risk factor, which means that multiple interventions are needed to target each of these risks. The aim of this review was to undertake a comprehensive evaluation of available literature on cardiovascular diseases, several associated risk factors (provided in two databases—Nuffield Health and Hampshire Health Record), and evidence-based interventions to effectively improve the individual's health and quality of life in the UK population. This review also aimed to compare the existing measurement of socioeconomic status and describe how the Indices of Deprivation 2007 were identified and applied to this study to assess different socioeconomic groups.

Search strategy

The databases were searched include the Cochrane Library, Medline, PubMed, and Embase between May 1980 and September 2012 with combinations of the terms: “cardiovascular disease”, “cardiovascular risk factors”, “risk factors”, “heart disease”, “coronary artery disease”, “CHD”, “CVD”, “body mass index”, “BMI”, “overweight”, “obesity”, “waist circumference”, “WC”, “waist-hip ratio”, “WHR”, “high blood pressure”, “blood pressure”, “elevated blood pressure”, “systolic blood pressure”, “diastolic blood pressure”, “elevated systolic blood pressure”, “elevated diastolic blood pressure”, “SBP”, “DBP”, “hypertension”, “cholesterol”, “total cholesterol”, “elevated total cholesterol”, “plasma cholesterol”, “lipids”, “low-density lipoproteins cholesterol”, “high-density lipoproteins cholesterol”, “LDL cholesterol”, “HDL cholesterol”, “elevated LDL cholesterol”, “elevated HDL cholesterol”, “socioeconomic group”, “socioeconomic status”, “education”, “income”, “occupation”, “profession”, “socioeconomic deprivation”, “area-level deprivation”, “area-level socioeconomic status”, “individual-level socioeconomic status”, and “neighbourhood

deprivation". Publications from the last 10 years were largely selected, but it did not exclude commonly referenced and highly regarded older publications. The search was restricted to publications in English. Further search of reference lists of articles identified by this search strategy was also done and those relevant articles were selected. Reviews are cited to provide readers with further details and additional references. Abstracts and reports from meetings were included when they related directly to previously published work.

There is a literature update between Sep 2012 and Dec 2013 with the same search strategy, and about 10 articles were included for this literature review.

3.1 INTRODUCTION

In this Chapter, the following cardiovascular risk factors—BMI, waist circumference, WHR, systolic and diastolic blood pressure, total cholesterol, HDL, LDL—will be discussed in full details in this literature review, because data on these risk factors are provided in two datasets—Nuffield Health and Hampshire Health Record, which will be analysed in the later chapters. Smoking, as an important risk factor contributed to cardiovascular disease and data are provided by the Nuffield Health's dataset, will be reviewed in this Chapter and analysed in Chapter 4 later. The prevalence of smoking is estimated around 30% of the adult population worldwide, with up to 47% in men and 12% in women (Mackay *et al.* 2002). Tobacco accounted for 18% of deaths in high-income countries (WHO 2009). Chapter 7 aims to compare the prevalence of various modifiable cardiovascular risk factors between Nuffield Health (private health screening) and Hampshire Health Record (NHS Trust), and to identify the similarities and differences of the two datasets in relation to the cardiovascular risk factors. Finally, this thesis will look at the effect of socioeconomic status, at both an individual-level (e.g. education, income, occupation, etc.) and area-level (e.g. IMD 2007), on cardiovascular risk factors, which both Chapters 5 & 8 will examine the effect of area-level socioeconomic status on many cardiovascular risk factors in the large UK populations.

3.2 RISK FACTORS FOR CARDIOVASCULAR DISEASE

The risk factor concept is an important feature for an individual's clinical assessment for initial or recurrent cardiovascular events. A risk factor is something that increases the chance of developing cardiovascular disease. The greater the combination of risk factors, the higher the probability of developing cardiovascular disease. The risk of a recurrent event is usually subject to indicators of the severity of the first event, but other influencing risk factors continue to play an essential part. On the basis of risk assessment, risk factors could be divided into modifiable or non-modifiable risk factors. Modifiable risk factors include diabetes, high cholesterol, hypertension (high blood pressure), obesity, sedentary lifestyle (physical inactivity), smoking, or exposure to environmental tobacco smoke. Non-modifiable risk factors (such as strong family history of cardiovascular disease) could nevertheless offer support for risk assessment, and could affect the urgency for correction of modifiable risk factors (Rosendorff 2005).

Worldwide, the two most important modifiable cardiovascular risk factors are high cholesterol and smoking (Emberson *et al.* 2003; Zipes *et al.* 2007). Obesity, diabetes, hypertension, and psychosocial factors are the next most important in the general population; however, their relative effects vary in different regions of the world (Yusuf *et al.* 2003). Excessive alcohol consumption is an additional important risk factor for a smoker. Many of these risk factors are unequally distributed across society, with the most deprived groups often exposed to the highest risks (Emberson *et al.* 2003; Yusuf *et al.* 2003).

Non-modifiable risk factors include age, especially for people older than 50 years, gender, genetic factors or family history of cardiovascular disease, and ethnicity. In the UK, South Asians have a particularly higher risk than do other ethnic groups. Also, people from Afro-Caribbean backgrounds have a higher than average risk of developing high blood pressure.

Cardiovascular risk factors could also be classified as major independent risk factors—age, cigarette smoking, diabetes, blood pressure >140/90 mm Hg, high-density lipoprotein (HDL) less than 1 mmol/l, raised low-density lipoprotein (LDL) concentrations, family history of premature coronary artery disease (first-degree male relative <55 years or first-degree female relative <65 years), and renal impairment; and lifestyle risk factors—obesity, physical activity and atherogenic diet (Yusuf *et al.* 2003).

3.3 HISTORICAL CONTEXT

Cardiovascular disease is a general term used to describe disorders that can affect the heart (cardio) and the body's system of arteries and veins (vascular), or both of them. This can lead to increased risk of heart attack, heart failure, sudden death, and even stroke, hence reducing quality of life and shortening life expectancy (Zipes *et al.* 2007; Durstine *et al.* 2008).

Globally, cardiovascular disease is the leading cause of death and is predicted to remain so (WHO 2011). Cardiovascular disease has a major effect on both developed and developing countries. About 17·3 million people died of cardiovascular disease in 2008 (WHO 2011),

accounting for 30% of overall global mortality, with other cardiovascular system diseases causing further mortality and disability.

During the last several decades, much progress has been made in establishing the determinants of cardiovascular disease and how to reduce the incidence and mortality. On the basis of this knowledge and the emerging evidence of the rising burden of cardiovascular disease worldwide, there has been a steady acceleration of international reports, declarations, and resolutions calling attention to the rising global epidemic of cardiovascular disease. The recent historical context is summarised in Appendix 3.1.

One of the first publications to highlight the global burden of cardiovascular disease was the 1993 World Development Report by the World Bank (1993). This report focused on the critical part that investments in health play in international development. The report also introduced the Global Burden of Disease study (1990), which definitively established that cardiovascular disease is responsible for more deaths worldwide than other cause.

As the realisation of the true global burden of cardiovascular disease began to grow among the international public health community, several major reports examined national capacities to implement prevention and treatment programmes for cardiovascular disease. These reports, most notably the 1999 World Heart Federation White Book, *The Impending Global Pandemic of Cardiovascular Diseases* (Achutti *et al.* 1999), and the 2001 WHO Assessment of National Capacity for Non-Communicable Disease Prevention and Control (Alwan *et al.* 2001), found that the majority of countries did not have cardiovascular disease and other chronic disease control policies, programmes, funding, or the will to take action. As a result, there was little prevention or control underway.

A series of reports from multilateral organisations further explored the growing burden of cardiovascular disease and other chronic diseases, which are shown in Appendix 2.1, including the 2000, 2002, and 2005 WHO Reports (WHO 2000a; WHO 2002a; WHO 2005b) and the Global Burden of Disease Reports in 2000, 2006, and 2008 (Jamison *et al.* 2006; WHO 2000b; WHO 2008b). Additionally, the Earth Institute/IC Health Report (2004) examined the social and macroeconomic effect of the growing epidemic of cardiovascular disease. Overall, these reports established that cardiovascular disease is the number one cause of death worldwide,

that the disease burden will only increase in the coming decades, and that control efforts are not sufficient to address the disease burden. These reports also recognised that cardiovascular disease is a complex issue, influenced by interdependent factors that involve many sectors and stakeholders extending far beyond the realm of health and public health systems.

Death rates from cardiovascular disease in England have been decreasing, but the disease still remains the main cause of mortality—up to 184,000 deaths—along with cancer and other chronic diseases in England and Wales in 2005 (National Statistics 2006). In 2003, around one per 300 people was newly diagnosed with some form of coronary heart disease in Scotland (SIGN 2007). Cardiovascular disease led to 28% of premature deaths (deaths in people younger than 75 years) in 2005 in England (National Statistics 2006). The government target is to reduce the mortality rate of cardiovascular disease in people younger than 75 years by a minimum of 40% from the 1995–97 baseline by 2010 (to 83.8 deaths per 100,000 population; DoH 1999). Although significant achievements in the prevention and treatment of cardiovascular disease in England in the last two decades, cardiovascular disease mortality was still up to 200,000 annually in the UK, there is much more to be done (DoH 2013), and one of many ways is to investigate the risk factors for cardiovascular disease and identify some outcomes strategies to deliver improvements in patient outcomes.

3.4 OBESITY

Obesity can be defined as an excess of body fat accumulation or adiposity, with specific multiple organ adaptive or maladaptive consequences. Energy imbalance or a chronic state of positive caloric balance is implicated as the cause of obesity. Obesity can be associated with enhanced risk of morbidity and mortality.

Assessment of anthropometric indices is an essential part of obesity management in clinical practice. These indices are helpful in defining the degree of obesity and reflecting regional fat distribution. The most commonly used anthropometric indices of obesity are: 1) body mass index (BMI); 2) waist circumference; 3) waist-to-hip ratio (WHR).

3.4.1 BMI

BMI is defined as weight in kilograms divided by the square of the height in metres (Sabia *et al.* 2009)—ie,
$$\text{BMI} = \frac{\text{weight (kg)}}{\text{height}^2 (\text{m}^2)}$$

The current thresholds are: a BMI of 18.5–25 kg/m² may indicate optimum adiposity; a BMI lower than 18.5 kg/m² suggests that the person is underweight; a number above 25 kg/m² may indicate the person is overweight; a number above 30 kg/m² suggests the person is obese; and over 40 kg/m², morbidly obese (WHO 2005; NICE 2006b). A WHO expert consultation discussed the BMI cutoff points for determining overweight and obesity in the Asian population, and made recommendations for population-specific thresholds for BMI (Barba *et al.* 2004). The research reviewed existing evidence that Asian populations have different associations between BMI, percentage of body fat, and health risks than do their European counterparts. It concluded that some Asian people have a high risk of type 2 diabetes and cardiovascular disease at BMIs lower than the recommended WHO cutoff point for overweight (≥ 25 kg/m²). However, available data do not indicate a clear BMI cutoff point for all Asians who are overweight and obese. The cutoff point for observed risk varies from 22 to 25 kg/m² in different Asian populations; for high risk it varies from 26 to 31 kg/m².

Globally, it was estimated by WHO (2008) that more than 1 billion adults 20 years or older were overweight (body-mass index [BMI] ≥ 25 kg/m²) and more than 500 million were obese in 2008 (BMI ≥ 30 kg/m²). The International Obesity Task Force estimates that at present at least 1.1 billion adults are overweight, including 312 million who are obese (James *et al.* 2004b). Figure 3.1 shows the average regional prevalence of obesity (not including overweight) by age and sex in the subregions of the world. These estimates, based on measured BMI in appropriate population samples, show that the only region in which obesity is not common is sub-Saharan Africa as a whole (Ezzati *et al.* 2005; James *et al.* 2004a). Excess bodyweight is now the sixth most important risk factor contributing to the global disease burden (Ezzati *et al.* 2002). At all ages and throughout the world, women are generally found to have a higher mean BMI and higher rates of obesity than are men, for biological reasons (James *et al.* 2004b).

According to WHO's (2009) estimation, average BMI is highest in the Americas, Europe, and the Eastern Mediterranean. In the USA, more than 70% of men and 60% of women were overweight or obese in 2003–04 (Ogden *et al.* 2006). In women, obesity is more common than overweight, demonstrating a marked skewness in the distribution of body-mass index (BMI). Ethnic differences in the prevalence of obesity showed that about 3% of non-Hispanic Whites are severe obese, as well as more than 5% of non-Hispanic blacks and about 2% of Mexican Americans (Ogden *et al.* 2006). Pleis *et al.* (2010) showed that the prevalence rate of obesity was 26.8% for women and 27.6% for men in 2009 in the USA. The prevalence of obesity in Canada is much lower than in the USA. A study showed an increase in the prevalence of obesity from 9% in 1981 to 14% in men in 1996, and in women, the figures were 8% in 1981 increasing to 12% in 1996 (Tremblay *et al.* 2002).

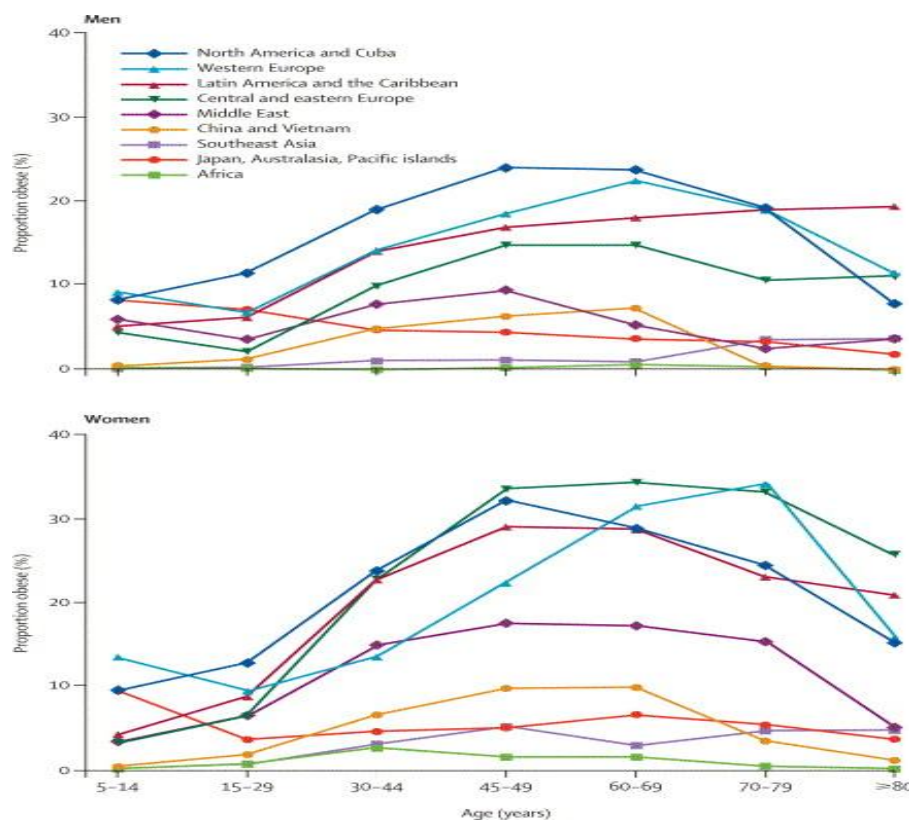


Figure 3.1. Prevalence of obesity worldwide, by age and sex (derived from Haslam and James [2005])

Doak *et al.* (2012) investigated the recent prevalence of overweight and obesity in Europe. This research was conducted on adults aged between 25 and 64 years in the period 1985–2005 in the 53 countries of the WHO European Region. In England, the proportion of men who were

overweight increased from 62.4% in 1991–95 to 70.9% in 2001–05, and the obesity rate increased from 15.6% in 1991–95 to 24.4% in 2001–05. In women, the figures for overweight were 50.0% in 1991–95, increasing to 57.2% in 2001–05, and obesity increased from 17.9% in 1991–95 to 24.3% in 2001–05. The increase in risk of death with each unit increase in BMI declines progressively with age but remains substantial until the age-group of 75 years and older (Stevens *et al.* 1998). Thus, the UK Government now estimates that a BMI of 25.0 kg/m² decreases the life expectancy of English men by two years and, given the progressive epidemic of obesity, the effect will increase to five years by 2050 (DoH 2004).

Romero-Corral *et al.* (2006) conducted an analysis of 40 studies including 250,000 people. Patients with BMI in the normal range were at higher mortality risk from cardiovascular disease than were people whose BMIs put them in the overweight range (BMI 25–29.9 kg/m²). Moreover, high cardiovascular mortality in patients in the study who were underweight (BMI <20 kg/m²) or severely obese (BMI >35 kg/m²) is growing. However, this finding is subject to confounding factors including many chronic diseases—for example, diabetes, which caused weight loss before eventual death. In view of this factor, higher mortality rates among slimmer people would be the expected result (Khalangot *et al.* 2009).

The simplicity of this method makes it ideal because the calculation requires only height and weight and it is inexpensive and easy to use for clinicians and for the general public. The use of BMI allows a person to compare their own adiposity status to that of the general population. Also, BMI correlates well with morbidity and mortality (Iacobellis 2009). However, the correlation between BMI and adiposity varies with sex, race, and age (Gallagher *et al.* 1996). BMI does have limitations in that, chiefly, it does not calculate the percentage of body fat. The NICE guideline (2006b) has generally acknowledged some limitations of the BMI model. BMI is dependent on weight and height, on the basis of distribution of muscle and bone mass, it could thus overestimate adiposity on individuals with more lean body mass such as athletes, while underestimating adiposity on those with less lean body mass such as the elderly people. In conclusion, BMI is merely an indicator of body fatness. It is simple to measure BMI. Also, the measurement of BMI is accurate and helpful in population surveillance and monitoring of trends in the prevalence of obesity. However, it needs to be remembered that BMI cannot distinguish between individuals who have a similar build but significant differences in regional body fat distribution and fat content.

3.4.2 Waist measurement

BMI does not distinguish between mass due to body fat and mass due to muscular physique. It also does not consider the distribution of fat. Therefore, it has been postulated that waist circumference could be a better measure than BMI to identify those with a health risk from being overweight (HSE 2008). Waist circumference provides an estimate of body girth at the level of the abdomen.

In accordance with the definition of abdominal obesity used by the US National Institutes of Health (NIH 2001) Adult Treatment Panel (ATP) III, a raised waist circumference is greater than 102 cm in men and greater than 88 cm in women. These levels identify people at risk of metabolic syndrome, a disorder characterised by increased risk of developing diabetes and cardiovascular disease. Given the fact that cardiovascular risk varies significantly with ethnicity, waist circumference is a helpful index of visceral adiposity among different racial groups. However, because of the significant differences in body size among different ethnic groups, specific high-risk waist circumference values have been proposed for each ethnic group, as summarised in Table 3.1.

Table 3.1: Ethnic-specific values for waist circumference

Country or ethnic group	Men	Women
European	≥ 94 cm	≥ 80 cm
South Asian, Chinese	≥ 90 cm	≥ 80 cm
Japanese	≥ 85 cm	≥ 90 cm
South and Central American	Use South Asian cutoff points until more specific data is available	
Sub-Saharan African	Use European cutoff points until more specific data is available	
Eastern Mediterranean and Middle East (Arab)	Use European cutoff points until more specific data is available	

In conclusion, waist circumference is a surrogate marker of visceral adiposity. It is a helpful tool in the clinical management of patients with increased visceral fat and increased cardiovascular risk who do not necessarily fit into the obese categories as defined by BMI. It

might be subject to operator variability and might lose sensitivity in severely obese patients. In some ethnic groups, such as Chinese and South-Asians, waist circumference is a better indicator of relative disease risk than BMI (Iacobellis 2009). Ethnic and age-related differences in body fat distribution can modify the predictive validity of waist circumference.

3.4.3 Waist-hip-ratio (WHR)

A WHR of 0.95 or higher in men or 0.8 or higher in women indicates increased cardiovascular risk. WHR is a powerful independent predictor of hypertension, diabetes, and coronary heart disease.

In Japanese-American men aged 71–93 years, Kalmijn *et al* (1999) found a positive association between quintiles of WHR and all-cause mortality, whereas quintiles of BMI were negatively related to all-cause mortality. Larsson and colleagues (1984) found that in men aged 54 years, mean WHR was higher in those who died than in those who survived a period of 4.5 years follow-up. However, a large WHR might not only reflect a large waist circumference, but also a small muscle area in the thigh measured, as shown by computed tomography (Seidell *et al.* 1989). Seidell *et al* (2000) also found that lean body mass was associated with decline of age in elderly population. The waist circumference is easier to interpret than WHR, especially in the elderly (Allison *et al.* 1995). Hip circumference reflects femoral and gluteal subcutaneous fat. Hip circumference in women can be explained mostly by variations in gluteal fat mass and pelvic width, whereas in men, muscle mass can be the main determinant of hip circumference.

3.4.4 Combined assessment of health risk from obesity

BMI is widely used in epidemiological studies to assess the risks of health outcomes associated with different levels of body weight. However, it does not measure body composition directly. Obesity refers to an excess of body fat. The underlying assumption of using BMI to define obesity is that at a given height, higher weight is associated with increased fatness (Benn 1971). However, BMI is an imperfect measure of body fatness, as it does not directly measure fat mass (Roche *et al.* 1981; Wellens *et al.* 1996). Some studies suggested that waist circumference, either alone or in combination with BMI, may have a stronger relation to smoking, obesity and

mortality, than BMI alone (Bigaard *et al.* 2003; Bigaard *et al.* 2005; Janssen *et al.* 2004; Visscher *et al.* 2001).

In the National Health and Nutrition Examination Survey (NHANES) data, Flegal and colleagues (2009) conducted a study of comparison of percentage body fat, body mass index and waist circumference in adults over 20 years old. They found that both BMI and waist circumference has a similar relation to percentage body fat and both were more highly correlated with each other than with percentage body fat. However, limitations were that percentage fat was based only on dual-energy X-ray absorptiometry (DXA) measurements, which was normally requires specialised DXA systems and X-ray exposure, and not on more complex body-composition models; waist circumference was measured just above the iliac crest, which might limit the comparability of the results with waist circumference measured in other anatomic locations. Also, there is question about the validity of the assumptions on the missing data. Finally, they concluded that BMI, waist circumference, and percentage body fat were all closely related, and, as percentage body fat increases, BMI and waist circumference increase. For men, waist circumference agreed slightly better than did BMI with categories of percentage fat. For women, BMI was associated with categories of percentage fat better than did waist circumference.

The UK guidelines issued by NICE (2006b) currently state that it is important to use both BMI and waist circumference in adults with a BMI less than 35 kg/m² when assessing health risks associated with overweight and obesity, which is shown below in Table 3.2.

Table 3.2: BMI classification (HSE 2008)

BMI classification	Waist circumference		
	Men 94 cm (37 in) or less Women 80 cm (31.5 in) or less	Men 102 cm (40 in) or less Women 88 cm (35 in) or less	Men > 102 cm (40 in) Women > 88 cm (35 in)
Underweight (<18.5 kg/m ²)	No increased risk	No increased risk	No increased risk
Normal BMI (18.5 to less than 25 kg/m ²)	No increased risk	No increased risk	Increased risk
Overweight (25 to less than 30 kg/m ²)	No increased risk	Increased risk	High risk
Obesity I (30 to less than 35 kg/m ²)	Increased risk	High risk	Very high risk
Obesity II (35 to less than 40 kg/m ²)	High risk	Very high risk	Very high risk
Obesity III (>40 kg/m ²)	Very high risk	Extremely high risk	Extremely high risk

3.5 HYPERTENSION

3.5.1 Background

Blood pressure is a result of the pumping action of the heart and the resistance of the vessels, through which the blood flows. Blood pressure varies during the day. It is normally highest around lunchtime or after exercise and lowest when people are resting or sleeping. Blood pressure is quoted as two numbers, the first number known as systolic blood pressure (SBP), the second as diastolic blood pressure (DBP). SBP is defined as the peak pressure in the arteries, which occurs near the beginning of the cardiac cycle when the ventricles are contracting; DBP is the lowest pressure during the resting phase of the cardiac cycle.

In Hutton's study, patients were classified (Table 3.3) into one of five groups on the basis of their SBP and DBP readings. The last three categories together are considered as hypertensive.

Table 3.3: Classification of blood pressure for adults (Hutton *et al.* 2008)

Classification of blood pressure for adults		
Category	SBP (mm Hg)	DBP (mm Hg)
Hypotension	<90	<60
Normal	90–119	60–79
Pre-hypertension	120–139	80–89
Stage 1 hypertension	140–159	90–99
Stage 2 hypertension	≥160	≥100

Since the late 1970s, the minimum blood pressure reduction for most patients with hypertension has been less than 140/90 mm Hg. The US National Heart, Lung and Blood Institute has issued several reports on high blood pressure (Chobanian *et al.* 2003; JNC 5 1993; JNC 6 1997). In its 7th report on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (Chobanian *et al.* 2003), the panel recommended an even lower rate for higher-risk patients, including those with diabetes or chronic renal impairment, to less than 130/80 mm Hg. The previous guideline (JNC 6 1997) recommended a target blood pressure of less than 125/75 mm Hg for patients with renal impairment and no more than a gram per day of urinary protein, which is no longer recommended. The American Heart Association guidelines (Rosendorff *et al.* 2007) have added patients with known coronary artery disease, carotid disease, peripheral arterial disease, or an abdominal aortic aneurysm and those with a calculated 10-year Framingham Risk Score of 10% or more to the group of high-risk patients with a blood pressure target of less than 130/80 mm Hg.

If an individual's blood pressure reading is consistently 140/90 mm Hg or above, this is considered high blood pressure and treatment is required. The high blood pressure reading can be either a systolic reading of 140 mm Hg or above, a diastolic reading of 90 mm Hg or above, or both. The target for the general population is to have a controlled blood pressure below 140/85 mm Hg. The latest guidelines from the British Hypertension Society (Williams *et al.* 2004) define blood pressure of 130/85 mm Hg or below as normal but say that 120/80 mm Hg is optimum. A blood pressure of 140/90 mm Hg is the typical level used to classify high blood pressure. Several European guidelines have been developed, and are mostly consistent with the requirements set by WHO/International Society for Hypertension, who set 150/95 mmHg as the threshold for treating low-risk patients, but lower this threshold to 130/85 mmHg for those with diabetes and renal disease.

3.5.2 Epidemiology

Hypertension is the second most important preventable cause of premature death in developed countries (WHO 2002a). Most hypertension patients have a blood pressure above the treatment goal of less than 140/90 mm Hg. Hence, uncontrolled hypertension can be regarded as a rampant but treatable risk factor. Although hypertension is common, its prevalence has not changed significantly in recent years. However, in the past 20 years, detection, treatment, and control of high blood pressure has progressively improved (Table 3.4). In the 1990s, however, there was an apparent levelling of effect in the USA, with many still unaware and ineffectively treated (Chobanian *et al.* 2003; Luepker *et al.* 2006). The estimation from National Institute for Health and Clinical Excellence (NICE) in the UK noted that 40% of adults in England and Wales have hypertension, using the threshold of 140/90 mm Hg (NICE 2006).

Table 3.4: Trends in awareness, treatment, and control of high blood pressure in adults with hypertension aged 18–74 years* (Chobanian *et al.* 2003)

	National Health and Nutrition Examination Surveys, weighted %			
	1976–80	1988–91	1991–94	1999–2000
Awareness	51	73	68	70
Treatment	31	55	54	59
Control†	10	29	27	34

*Data from the National Heart, Lung, and Blood Institute and data for National Health and Nutrition Examination Surveys

†Systolic blood pressure less than 140 mm Hg and diastolic blood pressure less than 90 mm Hg

The origins of high blood pressure are not well understood, however, associations with obesity, physical inactivity, salt intake, and alcohol intake suggest that behavioural factors play an important part. For example, overconsumption of salt causes up to 30% of all cases of hypertension (Joffres *et al.* 2007). Genetic factors are also apparent, but the high prevalence of hypertension suggests that any hereditary characteristics are very common in most populations. Also, in view of increasing life expectancy of the ageing population, it is expected that prevalence of hypertension in the community will rise.

3.5.3 Measuring blood pressure

An accurate reading requires that a participant not drink coffee, smoke cigarettes, or engage in exercise for about 2–3 hours before measuring their blood pressure. It also requires emptying of the bladder before the reading, since there might be an effect on blood pressure measurement. A systematic review compared trials of using BP lowering strategies conducted by Lv and colleagues (2012) has shown that the more intensive strategies reduced the BP of participants by 7.5/4.5 mmHg more than the less intensive strategies on average; more intensive BP lowering strategies reduced the risk of major cardiovascular events (a composite endpoint comprising heart attack, stroke, heart failure, and cardiovascular death) by 11%, the risk of heart attack by 13%, the risk of stroke by 24%, but did not have any clear impact on the risk of death or serious adverse events.

3.5.4 Causes of high blood pressure

Anyone can develop high blood pressure and its causes might be idiopathic and therefore unknown. Hypertension is the diagnosis for patients with persistent high blood pressure. A family history of high blood pressure plays a very large part in who does and does not develop high blood pressure. Generally speaking, at least half of the variance in blood pressure within large groups of people can be predicted from knowledge of blood pressure in parents, brothers, and sisters (Hart *et al.* 2000).

Stress can cause a large rise in blood pressure, lasting minutes or even hours (Rainforth *et al.* 2007). Such rises are normal and occur in everyone. They are brief additions to the usual average pressure, whether this pressure is high or low. The factors can also cause hypertension if being of Afro-Caribbean or South Asian origin, being obese, lacking of exercise, smoking, having excessive alcohol or salt consumption, and having high fat diet (Chaturvedi *et al.* 2012; Neter *et al.* 2003; Parikh *et al.* 2005; Schneider *et al.* 2005; Threapleton *et al.* 2013).

3.5.5 Prevention of hypertension

Lifestyle modifications including weight, exercise, and diet have the potential to prevent hypertension. They have also been found to be effective at lowering moderate hypertension with little risk and minimum cost. Although modification of lifestyle factors alone might not control high blood pressure, it could help to reduce the amount of antihypertensive drugs taken by the patient (Neaton *et al.* 1993). Excess bodyweight is associated with raised blood pressure. Weight reduction can reduce blood pressure in obese individuals with hypertension (Neaton *et al.* 1993); therefore, weight reduction is an important part of hypertension control. Recent research suggests that a diet lower in fat and higher in fruits and vegetables also results in lower blood pressure among people with mild hypertension (Krauss *et al.* 1998). Dietary fats, especially saturated fats, induce a rise in systolic and diastolic blood pressures as well as hypercholesterolaemia, as shown in the Dietary Approaches to Stop Hypertension (DASH) trials (Appel *et al.* 1997). Energy-dense diets rich in fats and refined sugars promote weight gain, and high sugar intakes also induce increases in blood pressure of 6·9 mm Hg (systolic) and 5·3 mm Hg (diastolic) (Drewnowski 1998; Raben *et al.* 2002; Stubbs *et al.* 1995). Energy density is reduced by higher intake of fruit and vegetables, which the DASH trial also showed lowered blood pressure.

Salt intake is particularly relevant to hypertension. Population surveys demonstrate strong association between population blood pressure and salt intake (INTERSALT Cooperative Research Group 1988). Migration studies where salt intake is greatly increased among people who migrate from low to high salt cultures is associated with increasing prevalence of hypertension (Joseph *et al.* 1983). Despite widespread information about the role of salt, considerable debate remains. The US National Dietary Goals recommend no more than 6 g of sodium chloride daily (Chobanian *et al.* 2003), but still well below the average intake. As the consumption of processed food increases, salt will play an increasing part in hypertension. The challenge, therefore, is to assess the contribution of weight gain as distinct from that attributable to dietary factors including salt (Sacks *et al.* 2001).

Physical inactivity also plays an important part in hypertension, with overweight individuals having up to 50% increased risk of developing high blood pressure. Moderate physical activity could control weight and potentially lower blood pressure (NIH 1996). Dietary factors also

have a role in precipitating or reducing hypertension. Alcohol consumption raises blood pressure. The National High Blood Pressure Education Programme recommends consumption of no more than 30 ml of ethanol as beer, wine, or whisky per day for men and 15 ml per day for women (Chobanian *et al.* 2003).

There was debate over the generalisability of hypertension trials to older adults and other groups; it is generally believed that the whole population will benefit from blood pressure lowering. Many medications are currently available for hypertension treatment; however, diuretics are recommended for initiating treatment because they have the longest clinical trial experience and a proven record of reducing morbidity and mortality in clinical trials (Chobanian *et al.* 2003; Furberg 2002).

3.5.6 Treatment of hypertension

An individual is unlikely to require treatment if he or she has a naturally low blood pressure. If an individual has postural hypotension, his or her treatment will depend on the underlying cause. For example, if a patient is on a drug that lowers blood pressure that had too strong effect, the doctor might switch the patient to a different type of drug to control the blood pressure. Diuretics and α blockers are examples of drugs that cause a dramatic drop in blood pressure. Most blood pressure drugs only lower the pressure back to normal. A slight reduction of SBP in adults of 2 mm Hg would save more than 14,000 lives per year in the UK (Critchley *et al.* 2003).

3.6 SERUM LIPIDS

3.6.1 Background

Cholesterol is an essential component of cell membranes, steroid-based hormones, and the bile acid that is produced by the liver. It is the main constituent of atheroma, which is deposited inside arterial walls and forms plaques. Cholesterol is required by the body to maintain health, and is found in the daily diet in meat, poultry, fish and other seafood, and dairy products, especially egg yolks.

Cholesterol is a lipid and cannot travel around the body unchaperoned, and thus it is carried around the body by proteins. These combinations of cholesterol and proteins are called lipoproteins. They are classified according to their density, and there are five components:

- Chylomicrons: these are the largest, and they contain the highest concentration of lipid.
- Very-low-density lipoproteins (VLDL): made in the liver.
- Intermediate-density lipoproteins (IDL)
- Low-density lipoproteins (LDL; commonly known as LDL-cholesterol): made in the plasma
- High-density lipoproteins (HDL; sometimes called HDL-cholesterol): these are the smallest, and they contain the lowest concentration of lipid; HDL maintains cardiovascular health, preventing the narrowing of the arteries (atherosclerosis) deposited by removing cholesterol from arteries to be disposed by the liver

The results from the Health Survey for England (HSE) 2006 showed that, although the prevalence of raised cholesterol concentrations is falling, cholesterol concentrations are still higher than recommended levels among individuals with, or at high risk of developing, cardiovascular disease.

3.6.2 Epidemiology

Keys and colleagues (1984) found that individuals with high cholesterol concentrations have increased risk of suffering from atherosclerosis and coronary heart disease compared with individuals with low cholesterol. Moreover, Stamler and colleagues (1986) found that the higher the level of cholesterol, the greater the risk of a coronary event. Furthermore, the principal determinants of blood lipid concentrations are dietary intake of cholesterol, polyunsaturated fat, and saturated fat (Clarke *et al.* 1997; Hegsted *et al.* 1993; Keys *et al.* 1957), although cholesterol concentrations are also affected by reduced energy intakes resulting in weight loss and genetic and other factors (Dattilo and Kris-Etherton 1992; Goldstein and Brown 1977). Much of the international variation in cardiovascular disease rates is therefore dietary in origin. Metabolic ward studies suggest that, in a typical western diet, replacing 60% of saturated fat intake by monounsaturated or polyunsaturated and avoiding 60% of dietary cholesterol would reduce blood total cholesterol (mainly LDL cholesterol) by about 10–15%

(typically about 0.8 mmol/L; Clarke *et al.* 1997). At a population level, this difference would be associated with about a 40% reduction in coronary disease in middle-aged patients (Lewington *et al.* 2007). Individualised intensive dietary advice has a more modest effect in free-living participants with typical reductions of about 6% in blood cholesterol, which tend to decrease over time (Tang *et al.* 1998). Moreover, reduction of LDL is the primary target for cardiovascular prevention, and statin-induced lowering of LDL has been shown to reduce the cardiovascular disease risk by about 30%.

3.6.3 Causes of high cholesterol

Saturated fat encourages the body to make more cholesterol than it needs or can eliminate. A cigarette smoker has about twice the risk of having a heart attack compared with a non-smoker. A smoker with high blood pressure and high cholesterol increases the chances of suffering a heart attack by more than eight times.

Other health conditions—for example, unsuccessfully controlled diabetes, certain kidney and liver diseases, and an underactive thyroid gland—could also cause high cholesterol. Some medicines such as β blockers, steroids, or thiazides (a type of diuretic) could also affect cholesterol levels (Indian Polycap Study [TIPS] 2009; Maron *et al.* 2010; Rosenstock *et al.* 2008; Rucker *et al.* 2007; Van Gaal *et al.* 2008).

3.6.4 Measuring lipid levels

LDL-cholesterol can be calculated indirectly by measuring total cholesterol, HDL-cholesterol, and triglycerides from a fasting venous blood sample and applying the Friedewald equation: $\text{LDL (mmol/l)} = \text{total cholesterol} - \text{HDL} - (\text{triglycerides}/2.2)$ (Friedewald *et al.* 1972). This method is not suitable for individuals with triglyceride levels higher than 5mmol/L. It is desirable to have a total cholesterol level less than 5mmol/l and an LDL level under 3 mmol/l on the basis of current UK guidelines (HSE 2008).

With respect to estimation of the risk of developing cardiovascular disease, the best indicator is the ratio of total cholesterol to HDL. A lower ratio is desirable, because this indicates that a person has high levels of HDL. For greatest accuracy, 12-hour fasting samples are required as

HDL-cholesterol and triglycerides levels vary between fasting and non-fasting states. HDL-cholesterol is lower by 5-10% in the non-fasting state than in the fasting state and triglyceride levels are 20–30% higher (Friedewald *et al.* 1972).

3.6.5 Prevention

High cholesterol is a major risk factor for cardiovascular disease, but it can be better controlled by a good diet and being physical active. The first approach in lowering cholesterol levels is to adopt an alternative diet. Most people can reduce their cholesterol level by 15–20% by reducing their intake of foods that are high in cholesterol and fat, especially saturated fat. The recognition that usual food intake is a behaviour strongly related to culture and food availability has resulted in community-based public health strategies to improve dietary intake. The North Karelia and Stanford Three Town Studies were among the first to use public and health professional education about dietary fat to reduce cholesterol level (Farquhar *et al.* 1977; Puska *et al.* 1995). In both studies, an improved eating pattern with reduced saturated fats resulted in reduced average cholesterol levels in these small communities. Larger studies in medium-sized cities in Europe and the USA showed similar results. Strong favourable secular trends in control communities resulted in modest differences in cholesterol levels (GCP Research Group 1998; Farquhar *et al.* 1990; Luepker *et al.* 1994; Carleton *et al.* 1995).

Blood cholesterol levels continue to be predictive in adults older than 65 years, although the relative risk is reduced (Abbott *et al.* 1997). Blood cholesterol can be lowered in adults with moderate changes in diet and loss of weight. A progressive fall reported in blood cholesterol levels in the USA was associated with changes in the habitual diet during the past 25 years (Carroll *et al.* 2005; Arnett *et al.* 2005).

Evidence from a meta-analysis including 90,056 participants in 14 randomised trials of statin therapy showed that a 1.0 mmol/L reduction in LDL cholesterol reduced the 5-year relative risk of a major vascular event by 21%, irrespective of sex, age, blood pressure, pre-existing diabetes, or history of a previous vascular event (relative risk 0.79, 95% CI 0.77–0.81; $p < 0.0001$; absolute risk reduction 3.7%; Baigent *et al.* 2005). A number of large secondary prevention trials using statin therapy to lower cholesterol have also been completed, including

the Scandinavian Simvastatin Survival Study (Scandinavian Simvastatin Survival Study 1994). It demonstrated a significant reduction in all-cause mortality, coronary heart disease mortality, coronary events, and revascularisation procedures in patients with known coronary heart disease. The Cholesterol and Recurrent Events trial and the Long-Term Intervention with Fibrostatin in Ischaemic Disease trial also demonstrated cholesterol reductions associated with fewer major coronary events (Sacks *et al.* 1996; LIPID Study Group 1998). The MRC/BHF Heart Protection Study resulted in a 25% reduction in cardiovascular events with simvastatin in 20,536 high-risk patients (Collins *et al.* 2002)

3.6.6 The benefits of lowering cholesterol for cardiovascular risk

There is consistent evidence from clinical trials of the benefits of reduced total cholesterol and LDL cholesterol. There is also a suggestion that raising HDL cholesterol adds to these beneficial effects. A Finnish trial in men with known coronary heart disease resulted in a significant reduction of coronary events associated with increased HDL cholesterol and decreased triglycerides. Total cholesterol results were variable (Frick *et al.* 1987). A more recent treatment study of men with average total cholesterol but high LDL cholesterol with gemfibrozil also produced positive results. HDL cholesterol increased in the treatment group compared with placebo. Coronary events were reduced. Serum triglycerides also fell significantly, raising questions about the relative importance of the two lipid effects (Rubins *et al.* 1999).

Several trials have showed that reducing cholesterol levels decreases fatal and non-fatal myocardial infarction without increasing death from other causes. An 11% reduction in total cholesterol is associated with a 23% decrease in cardiovascular events. However, even a strict low-fat diet might result in only a 5% reduction in total cholesterol levels (Aron 2004; Handler 2004).

In more recent randomised control trials of lipid lowering, LDL has been targeted for therapy. In patients with and without cardiovascular disease, trials have specified the degree of relative risk reduction for major coronary events using statin therapy. The risk reduction could be achieved from a given lowering of LDL. Evidence showed that relative risk for major coronary

events is reduced by approximately 1% for every 1% reduction in LDL cholesterol levels (ALLHAT Offices and Coordinators for the ALLHAT Collaborative Research Group 2002; Heart Protection Study Collaborative Group 2002; Shepherd *et al.* 2002; Sever *et al.* 2003).

The National Service Framework (NSF 2000) published guidelines for those with, or at high risk of developing, cardiovascular disease, giving a treatment threshold for total cholesterol at 5.0 mmol/l, The Joint British Societies produced their second national treatment guidelines (JBS 2) for those at risk of cardiovascular disease in December 2005 (JBS2 2006). High risk individuals were recommended a lower cholesterol level threshold of 4.0 mmol/l. In January 2006, NICE published its Health Technology Appraisal of statins, which found that they were both clinically and cost effective for patients at risk of developing cardiovascular disease (NICE 2007). NICE is currently developing Clinical Guidance for the primary and secondary prevention of cardiovascular disease (HSE 2008).

3.7 SMOKING

3.7.1 Background

Smoking is defined as a practice where a substance, most commonly tobacco, is burned and the smoke tasted or inhaled. The most common method of smoking today is through cigarettes. It is primarily manufactured by industries, but also hand-rolled from loose tobacco and rolling paper. Other forms, though not as common, are pipes, cigars, hookahs, and bongs (Slovic 2001; WHO 2002a).

Smoking is one of the most common forms of recreational drug use. Tobacco smoking is the most popular form of smoking and is practised by over 1 billion people across the world (Neovius *et al.* 2009). Every day more than 1 billion people smoke or chew tobacco because of their addiction to nicotine, and about 15 000 die from tobacco-related diseases; tobacco use accounts for half the health inequalities, as assessed by education, in male mortality (Jha *et al.* 2006). Tobacco use has fallen in many high-income countries, at least in men, but is now rising rapidly in many low-income and middle-income countries with a prevalence of more than 25% in adolescents in some countries. This rise is due to the tobacco industry's uncontrolled

activities and persistent efforts to influence and weaken tobacco control policies (Freeman and Chapman 2010; Malone 2010).

3.7.2 Demographics

The World Health Organization (WHO) states that much of the disease burden and premature mortality contributed to tobacco use excessively affect low-income individuals. Of the 1.22 billion smokers, 1 billion of them live in low-income and middle-income countries (Mackay *et al.* 2002). While up to 30% of men are former smokers in industrial countries, only 2% of men from China have quit, and 10% in Vietnam (WHO/WPRO-Tobacco 2007). Rates of smoking have stabilised or declined in high-income countries; the rate in the USA lowered by half from 1965 to 2006, from 42% to 20.8%, in adults (Rock *et al.* 2007). From 2002, the consumption of tobacco has risen at a rate of 3.4% per year in high-income countries (WHO 2008b).

The prevalence of smoking is estimated around 30% of the adult population worldwide (47% in men and 12% in women; Mackay *et al.* 2002). If the growth dropped from the current rate by 1% per year, there is a net growth of 2%, which would lead to an estimated number of smokers of 1.3 billion between 2010 and 2025 (Guindon *et al.* 2003).

Smoking was generally five times higher among men than women in the 1990s (Guindon *et al.* 2003), however the gender gap is smaller at younger ages (CDC 2001; WHO 2002b). As of 2002 in China, 67% of men smoke and 4% of women; however, among teens the gap closes to 33% among men and 8% in women (WHO 2002b). In developed countries, smoking rates for men have peaked and have begun to decline; however, for women they continue to climb (Peto *et al.* 2006).

An estimated 13 million people smoke in the UK, with an equal proportion of males and females. In 2006, it is reported that 24% of men and 21% of women smoked smoking cigarettes. Prevalence of cigarette smoking differs by sex and by age, and is highest among men aged 25–34 years, which accounts for 34%, and among females aged 16–24 years, which accounts for 28% (HSE 2008). It is becoming more and more common in younger generations, so it is

important to start education at school-age, with particular focus on prevention programmes (Kmietowicz 2008), because it can become an addiction shortly after developing the habit.

Research has showed that middle-aged men who smoke more than 20 cigarettes a day have a two to three times higher risk of a major cardiac event compared with non-smokers of the same age (Byberg *et al.* 2009). The risk of developing coronary heart disease (CHD) is dose related. Smoking raises blood pressure, which can cause hypertension – a major risk factor for heart attacks and stroke. The cardiovascular morbidity and mortality risks for women are similar to those for men, but the risk of fatal myocardial infarction is 13 times higher if they use the oral contraceptive pill (Wilson *et al.* 2000).

It is estimated that 114,000 deaths in England per year are directly attributable to smoking and 30,600 die from cardiovascular disease (HSE 2008). The government is committed to reducing the number of people smoking; the target set for smoking rates among adults should be 21% or less by 2010, with a reduction in prevalence among manual group to 26% or less (HSE 2008). It is widely recognised that levels of smoking vary between different socioeconomic groups; it is more prevalent in those of lower socioeconomic class and lower educational status (Townsend *et al.* 1998). In 2004, the government set out its strategy to tackle smoking, its effects other people in the white paper, Choosing Health (DoH 2004). The report contained a number of initiatives to reduce smoking prevalence and announced a commitment to establishing smoking-free public places.

Smoking is the single largest cause of death, disability, preventable illness and unnecessary health expense in the UK (Handler 2004). It is approximately caused 17-30% of all cardiovascular deaths (Lyratzopoulos *et al.* 2006). It has showed that the lifespan would be shortened by the smoking to an estimated 10 years. About 50% of smokers die of a smoking-related illness (Lyratzopoulos *et al.* 2006; HSE 2008).

The risk of CHD falls by 50% one year after cessation, and after four years it is similar to that for a person who has never smoked (Peto *et al.* 2000). This benefit also applies to smokers aged over 60 years (Aveyard *et al.* 2007). Smoking cessation should be the main focus of risk reduction for patients with vascular disease, and should be managed like heroin and cocaine addiction. Stopping smoking reduces the 10-year risk of deaths by over half (from 54% to 18%)

(Aveyard *et al.* 2007). It is the single most important intervention conferring the greatest symptomatic and prognostic benefit. Table 3.5 below shows the timeline of health benefits after stopping smoking.

Table 3.5: Timeline of health benefits after stopping smoking (WHO 2002b; WHO/WPRO 2007)

After...	Health Benefit...
72 hours	Breathing becomes easier. Bronchial tubes begin to relax and energy levels increase
1 month	Skin appearance improves owing to improved skin perfusion
3–9 months	Cough, wheezing, and breathing problems improve and lung function increases by up to 10%
1 year	Risk of a heart attack falls to about half that of a smoker
10 years	Risk of lung cancer falls to about half that of a smoker
15 years	Risk of heart attack falls to the same level as someone who has never smoked

3.8 SHARED RISK FACTORS AND THEIR CAUSES

The main risk factors for cardiovascular disease for individuals are well known and are similar in all countries. Tobacco use, foods high in saturated and trans fats, salt, and sugar (especially in sweetened drinks), physical inactivity, and the harmful consumption of alcohol contribute to more than one-thirds of all new cases of cardiovascular disease and increase the risk of complications in people with cardiovascular disease (Yusuf *et al.* 2004).

Changes in the social and economic environment have resulted in the risk factors for cardiovascular disease becoming widespread (Geneau *et al.* 2010). Socioeconomic factors have been recognised as playing a major role in both developed and developing countries.

In conclusion, the prevalence of cardiovascular disease is high in the UK—over 3 million people currently suffer from this disorder. Although the burden of cardiovascular disease is large, 80–90% of premature cardiovascular mortality is preventable. At the same time, dietary risk factors for high blood pressure, cholesterol and obesity, coupled with insufficient physical activity, are responsible for an increasing proportion of the cardiovascular disease burden. In the chapters 3 & 7, it will examine the prevalence of these cardiovascular risk factors (above mentioned) in affluent UK populations both from the private medical insurance company and

NHS Trust. In the following section, we will look at the prevention of cardiovascular disease and associated risk factors.

3.9 INTERVENTION STRATEGIES

3.9.1 Tobacco control

Cardiovascular disease is the most common smoking-related cause of death, especially in the age range between 35 and 69 years, in which 25% of deaths are attributable to tobacco (Doll *et al.* 2004). Mortality after myocardial infarction is lower in patients who stop smoking compared with those who continue smoking (CDC 2009). Furthermore, it declines dramatically after stopping smoking when assessing the risk of coronary events. The risk of such events is similar to that for individuals who have never smoked after 2–3 years of abstinence (Unal *et al.* 2005).

In a health policy paper published by *The Lancet*, Beaglehole *et al.* (2011) suggested that the priority for immediate action is to achieve by 2040 of a world essentially free from tobacco where less than 5% of the population use tobacco. 5·5 million deaths over 10 years in 23 low-income and middle-income countries with a high burden of cardiovascular disease and other non-communicable diseases could be saved if four of the Framework on Tobacco Control strategies are fully implemented (Asaria *et al.* 2007). This strategy will have immediate health and economic benefits as reduction in exposure to tobacco smoke, both direct and second hand, will reduce the burden of cardiovascular disease within one year and thus health expenditures (Lightwood and Glantz 1997; Sims *et al.* 2010)

2.9.2 Salt reduction

Reduction in salt consumption is the other top priority intervention strategy for cardiovascular disease because it will cause lower blood pressure, one of the main risk factors for stroke and heart disease. Reduction of population-wide salt consumption by only 15%—through mass-media campaigns and reformulation of food products by industry—would avert up to 8·5 million deaths in 23 high-burden countries over 10 years (Asaria *et al.* 2007). In the long term, the reduction in salt consumption will have a greater effect since reduced intake will decrease the age-associated higher blood pressure, and any small risk of iodine deficiency can be

addressed by other means (Verkaik-Kloosterman *et al.* 2010). Salt substitution in countries such as China, where much of the salt is added during cooking and eating, will be a useful strategy (CSSC Group 2007). As the consumption of processed foods rises in many countries, a change in the industry norms to reduce the addition of salt now will have important benefits in the future, although government regulation might be needed. Suggestion is to reduce worldwide salt intake to less than 5 g (or 2000 mg sodium) per person per day by 2025 (Cobiac *et al.* 2010; WHO 2007).

3.9.3 Promotion of healthy diets and physical activity

Physical inactivity is epidemic in most industrialised societies and is becoming more so in the developing world. There is considerable debate over public health recommendations for physical activity, including the amount, type, and duration of physical activity needed to obtain beneficial cardiovascular effects, as well as the issue of fitness. Finally, the association of vigorous physical activity with sudden death has increased concerns regarding advice. Considering these factors, several recommendations have emerged in recent years, however, only moderate cardiovascular gains accrue from this addition (NIH 1996). People need sufficient activity to increase the heart rate and breathing rate. Regular physical activity will lead to increased fitness; however, much of the association with fitness might be genetically determined rather than the result of training alone (Sofi *et al.* 2008). Nonetheless, observational study did show that physical fitness is associated with reduced rates of cardiovascular disease (Sofi *et al.* 2008). Also important is that people have five portions of fruit and vegetables daily can protect against heart disease and stroke (Lancet 2010).

Health policies in promoting physical activity and the consumption of foods low in saturated and trans fats, salt, and sugar—particularly sugar-sweetened drinks—will lead to wide-ranging health gains, including preventing overweight (especially in children), cardiovascular disease (Lock *et al.* 2005). The main interventions is to increase the price of high saturated food, industrially produced trans fats and sugar; food labelling; and marketing restrictions of unhealthy food products, specifically in children and young people (WHO 2004). All countries' governments should make compulsory regulatory and fiscal measures for food industry to reformulate processed foods and stop the promotion of unhealthy products to children. Agricultural subsidies, and trade and capital market liberalisation have contributed to reduced

prices and increased availability of unhealthy products, and to the increasing rates of risks now noted among young people, leading to a rapid rise in the proportion who are overweight (Rayner *et al.* 2006). Modification of the built environment to promote physical activity also has the potential to prevent obesity, and although it would be more challenging initially, could rapidly advance as a co-benefit of climate control methods (Chow *et al.* 2009; Younger *et al.* 2008).

3.9.4 Reduction of harmful alcohol consumption

Policies that affect the price, promotion, and availability of alcohol reduce alcohol-related harms (Anderson *et al.* 2009). Enforced legislation that reduces drink-driving, and interventions for at-risk drinkers are also effective. In countries with high amounts of unrecorded production and consumption, an important strategy is to increase the proportion of alcohol that is taxed; it requires effective policing of illegal and informally produced alcohol. The imposition of a tax based on alcohol content is an essential complement to increased taxes. In most countries, and globally, alcohol marketing and sponsorship are widespread and, as with tobacco, legislative responses are needed to reduce harmful consumption of alcohol.

3.9.5 Access to essential drugs and technologies

Universal access to affordable and good-quality drugs for cardiovascular disease is an important issue for all countries, and especially low-income and middle-income countries. This issue also arises in the treatment of HIV infection and AIDS; an integrated approach is needed for the treatment of all priority diseases with special attention to reducing inequalities (Beaglehole *et al.* 2011).

The best evidence-based clinical approach in low-income and middle-income countries is a multidrug combination for people identified opportunistically in primary care as being at high risk of cardiovascular disease, or for patients who have already had a clinical event (Lim *et al.* 2007). WHO has produced risk assessment charts that can be further simplified by removal of the need for a blood sample (Gaziano 2008; WHO 2010). Scale-up of this intervention would, over 10 years, avert 18 million deaths from cardiovascular disease in 23 high-burden low-

income and middle-income countries at a cost of about US\$1.08 per person per year (Lim *et al.* 2007).

3.10 SOCIOECONOMIC STATUS

3.10.1 Measurement of socioeconomic positions

Socioeconomics is the study of the relationship between economic activity and social life (van Jaarsveld *et al.* 2007; Myint *et al.* 2009). It has emerged as a separate field of study in the late twentieth century (Rask *et al.* 2009). Socioeconomic status has been defined as a descriptive term for a person's position in society, which may be expressed on an ordinal scale using such criteria as income, educational level obtained, occupation, value of dwelling place, etc.

3.10.1.1 Occupation

Occupational measures have been widely applied to research in public health. Occupation is categorised into defined ranks such as professional, managerial, clerical, non-manual and manual (Singh-Manoux *et al.* 2008). The use of occupational measures is limited by their lack of applicability to "economically inactive" people such as "home-keepers" (particularly women) and beneficiaries. The classification (Nordstrom *et al.* 2007; Rask *et al.* 2009) which is popularly used has been divided into the following grades: A (upper middle class) – professional or at director level; B (middle class) – senior management; C1 (lower middle class) – junior management and clerical; C2 (working class) – skilled; D (working class) – unskilled, manual labour; and E – those reliant on the state, such as pensioners and the long-term unemployed. Occupation is one of the social determinants that is independently associated with cardiovascular risk factors (Gregory *et al.* 2007; McFadden *et al.* 2008).

Although occupation as a measure of social class has been widely used in the public health research, it has several disadvantages (Kaplan and Keli 1993). First, considerable information should be collected about individual's occupational history, it would be useful to reflect more than current occupation by classification, and easily identify the effect of disease. Moreover, although the same occupation, but in different organisations, it meant different social status.

For example, a chief executive officer of a large multinational corporation and a proprietor of a small family business would be the same rank in some systems, or a skilled manual worker might have an income that considerably exceeds a university professor's income. Therefore, a classification on the basis of characteristics such as decision latitude, time pressure, intellectual discretion, and other job-related characteristics provided a better way of grouping occupations with respect to socioeconomic status. Second, there is a need for accurate rankings including rapid changes in the existence and status of new occupations, as well as those who do not work or who are housekeepers. Finally, socioeconomic status scales on the basis of prestige rankings could be faulted for their inherent subjectivity.

3.10.1.2 Income

Income-based measures exhibit consistently strong associations with health status (Nagpal *et al.* 2008; Schulz *et al.* 2008; Shaw *et al.* 2008). Measuring income is, however, “a complex process and these measures are unable to capture the socioeconomic circumstances of some population subgroups whose taxable incomes are prone to miscalculation”. Examples would include self-employed and retired people. Findings in a US survey by the National Health and Nutrition Examination showed that the prevalence of hypertension decreasing from the lowest to highest income groups. Similar findings were also found in Finnish men from three regions (Harald *et al.* 2008; Kanjilal *et al.* 2006).

3.10.1.3 Education

Educational measures are relatively less complex and tend to be fixed after young adulthood (Sainio *et al.* 2007). Roohafza and colleagues (2005) found a negative association between educational level and some cardiovascular risk factors such as cholesterol, blood pressure, and BMI, but no statistical significance was shown between smoking and educational level. A cross-sectional study assessed hypertension in an urban working population in Ghana showed negative association between the level of education and hypertension after controlling for the other measures of social indicators (Addo *et al.* 2009). Although educational measures can be used in most people, they do not discriminate adequately between population subgroups

(Reddy *et al.* 2007), e.g. the link between a given level of education and its "economic return" varies by gender and by ethnicity in the UK.

3.10.1.4 Profession

Using professional classification, Emberson *et al.* (2004) found that BMI was higher in manual than non-manual UK workers. Puslaw (2008) found that higher BMI values with decreasing professional classifications. Dragano *et al.* (2005) found that people having the least education were twice as likely to be obese than the most educated in Czech. This ratio was 1.6 in Germany. Stafford and colleagues (2010) found that residence in a more deprived neighbourhood contributed to a higher initial BMI when the study started. There was also a note that in this longitudinal, multilevel Whitehall II study of 13 years follow-up using the Townsend index of multiple deprivation at census-ward level, participants from the most-deprived neighbourhoods experienced relatively greater weight gain over time, an increase of 1.5kg/m² in men and 1.4kg/m² in women. Wang *et al.* (2007) gathered five cross-sectional surveys conducted by the Stanford Heart Disease Prevention Programme between 1979 and 1990 and found that participants from low socioeconomic neighbourhoods had a higher mean BMI than those from high socioeconomic neighbourhoods, after adjusting for age, gender, ethnicity, individual-level socioeconomic status, smoking, physical activity and nutrition knowledge. Similar finding has also been assured in GLOBE study (van Lenthe and Mackenbach 2002) that odds ratios of BMI increased significantly with increasing neighbourhood deprivation, after adjusting sex.

3.10.1.5 Area-level measures

Chen and Tunstall-Pedoe (2005) conducted the Scottish MONICA survey in 2,233 men and 2,516 women aged 25-64 years to investigate the relationship of waist circumference to socioeconomic deprivation, measured by Carstairs Index. In the cross-sectional survey, they also compared the relationship of waist circumference to WHR and BMI and found that large waist circumference has a closer relationship than WHR and BMI to the socioeconomic deprivation in men and women, although waist circumference, WHR and BMI increased with level of deprivation significantly in both sexes. The Kuopio Ischemic Heart Disease Risk

Factor Study found that after adjustment for smoking, hypertension, dyslipidemia, and diabetes resulted in a modest (24%) attenuation of the relative socioeconomic gradient of CHD risk, the most deprived groups are still have higher risks compared with those in the least deprived groups. These risk factors accounted for most (72%) of the absolute socioeconomic gradient (Lynch *et al.* 2006).

3.10.2 Rational for using English Indices of Deprivation 2007

Deprivation indices are defined as a measurement for a group of individual residing in a specific geographic area having similar environmental conditions (Abu-Kharmeh *et al.* 2009). Deprivation indices are referenced as low or high weights for living and service needs indicated, or both of them (Morris *et al.* 1991). Deprivation measurements often refer to geographic areas rather than individuals, they are indicative for the whole society that lives in a specific area (Lee *et al.* 1995).

Deprivation indices are easier to be used in practice than most other measures of socioeconomic status (Galobardes *et al.* 2006), and have subsequently become accepted among researchers into public health, especially when personal data are not able to access.

It is usually a debate in social sciences among scholars and researchers about the issue of poverty studies and construction of their analysis on expenditure and income, while analysis of deprivation studies are built on many other important socioeconomic issues, namely deprivation of income, health, education and the deprivation from adequate access to services (Townsend *et al.* 1988). Deprivation issues have heavily been discussed in the developed world. There are numerous examples of use of indices of deprivation in health research, particularly in the UK (Adams *et al.* 2005).

The English Indices of Deprivation (ID) 2007 (Noble 2007) are the Government's official measure of multiple deprivation on a small area scale. Their purpose is to identify priority areas, inform resource allocation, to help assess the impact of regeneration policies and to measure progress in implementing the National Strategy for Neighbourhood Renewal. These aim to narrow the gap between the most affluent and deprived neighbourhoods in the country.

The ID 2007 is the third set of indicators to be published in seven years; the first being published in 2000 (Noble 2000) and then again in 2004 (Noble 2004). The Indices are used widely to analyse patterns of deprivation, as well as identifying areas that would benefit from special Government initiatives or programmes. The ID 2007 provides a relative ranking of areas across England according to their level of deprivation.

The new Index of Multiple Deprivation 2007 (IMD 2007) is a lower layer super output area (LSOA) level measure of multiple deprivation, and is made up of seven LSOA level domain indices. The IMD 2007 combines a total of 38 indicators, which is distributed across the seven domains, covering a range of social and economic issues to produce a deprivation score for each small area of England. The IMD 2007 score is termed “the combined sum of the weighted, exponentially transformed domain rank of the domain score”. There are 32,482 of these small areas – known as lower level super output areas, or LSOAs – in England, each containing between 1,000 and 3,000 people, an average population of 1,500 people. The bigger the IMD 2007 score, the more deprived the LSOA. However, because of the exponential distribution, it does not mean that a LSOA with a score of 40 is twice as deprived as a LSOA with a score of 20. In order to make direct comparisons between LSOAs it is recommended to use ranks. Each area is then ranked nationally from 1 (most deprived) to 32,482 (least deprived). By producing a score for each of these it is possible to compare relative levels of deprivation between areas.

It is important to remember that the Index of Multiple Deprivation 2007 is a relative not an absolute measure of deprivation. The purpose of the Indices is to identify small areas of England which are experiencing multiple aspects of deprivation. The Indices of Deprivation is a comparator indication; it measures how much we have improved in comparison with other areas, not absolute improvements. Being a relative measure, there will always be, for example, 10% of areas that are defined as the most deprived 10%, even if significant improvements are made to the absolute levels of deprivation in the country. When examining the most deprived 10% of areas it is therefore important to remember that the absolute level of deprivation experienced by people living in these areas may vary between years.

When considering the various domain indices, the overall rank of an LSOA may not change, but this does not mean there have been no changes to the level of deprivation. Conversely, an area may increase or decrease in rank without any actual change in levels of deprivation

occurring. This reflects the fact that all change is relative. For example, if an area sees no change in the rate of income deprivation between two Indices but other LSOAs do improve their figures, the LSOA in question may have a lower domain rank because it has been ‘overtaken’ by other LSOAs, even if its score is the same in both years.

Equally, when comparing the overall Index of Multiple Deprivation, if improvements in one domain are offset by a decline on another domain, the overall Index of Multiple Deprivation position may be the same even if significant changes have occurred to the domains.

3.10.3 Explanation of calculating Index of Multiple Deprivation 2007 score

The IMD, in general, is defined as a weighted area level aggregation of these specific dimensions of deprivation. The IMD2007 is subdivided into seven different “domains” of deprivation (Noble 2007). Every domain is given a specific weight, according to its importance, totalling 100%. Table 3.6 summarised domain weights for the IMD 2007.

Table 3.6: Domain Weights for the IMD 2007 (Department for Communities and Local Government 2008)

	Domain Weight
Income Deprivation Domain	22.5%
Employment Deprivation Domain	22.5%
Health Deprivation and Disability Domain	13.5%
Education, Skills and Training Domain	13.5%
Barriers to Housing and Services Domain	9.3%
Crime Domain	9.3%
Living Environment Domain	9.3%

3.10.4 Data limitations

- The ID 2007 cannot be used to determine ‘how much’ more deprived one LSOA is than another as it is a relative measure of deprivation
- The ID 2007 scores and ranks are not able to be used as absolute measures of deprivation or to identify absolute change over time.

- The ID 2007 identifies concentrations of deprivation, which means not all deprived people live in deprived areas, vice versa, not everyone living in a deprived area is deprived.
- The ID 2007 is not a measure of affluence. The indicators which have been used have been chosen because they represent different aspects of deprivation. A lack of deprivation does not necessarily mean to affluence. Therefore, the LSOAs with the highest ranks (i.e. close to 32,482) are not necessarily affluent, just less deprived.
- The Index scores from 2004 cannot be compared with those from 2007. Although the two Indices are very similar, it is not valid to compare the scores between the two time points they are relative to each other but not comparable. An area's score is affected by the scores of every other area; so it is impossible to tell whether a change in score is a real change in the level of deprivation in an area or whether it is due to the scores of other areas going up or down.
- The Indices are for England only.

3.10.5 Establishing deprivation index from postcode

The National Statistics Postcode Directory (NSPD) (National Statistics 2007) is a list of all the current and terminated postcodes that have ever existed in the UK, together with geographical links or matches for each postcode to a variety of different administrative, health, electoral and other geographies that are, or have been, used within the UK.

The information contained within the NSPD has a wide range of potential uses across a broad range of disciplines wherever postcode data is used, or where information on the relationships between different geographies, or changes in a single geography over time is required.

GeoConvert (GeoConvert 2007) is an online service available from the Census Dissemination Unit (CDU). It uses information originated from the NSPD which is used to work with the dataset directly to supply functions to perform a range of the tasks. Functions provided by Geoconvert allow users to convert postcodes to deprivation scores.

Socioeconomic status is one of the strongest predictors of morbidity and premature mortality of cardiovascular disease (Winkleby *et al.* 1992). In Chapters 4, data on postcode were

provided by the Nuffield Health, and it would be used to transfer to IMD 2007 score. This will help to measure socioeconomic status in an area-level, which is distinct from individual socioeconomic position. It will also assess the effect of this area-level socioeconomic status on modifiable cardiovascular risk factors in this affluent population who attended the Nuffield Health. The advantage of using IMD 2007 in this research is because it is made up of seven lower layer super output area level domain indices. The IMD 2007 combines a total of 38 indicators, which is distributed across the seven domains, covering a range of social and economic issues to produce a deprivation score for each small area of England. This method does not apply to Chapter 8, because the socioeconomic groups were provided (groups 1-10, and then merged to 5 groups) by the Hampshire Health Record. Chapter 8 will also compare the effect of socioeconomic status on cardiovascular risk factors in these two populations.

3.11 CONCLUSIONS

Cardiovascular disease and other non-communicable diseases have been categorised as a top priority against premature death and preventable morbidity and disability worldwide, and the UN High-Level Meeting on Non-Communicable Diseases has been held at New York in September 2011 to discuss the strategy of tackling these diseases. Six objectives has been addressed in a published report, *2008-2013 Action Plan for the Global Strategy for the Prevention and Control of Non-communicable Diseases*—raising the priority accorded to non-communicable disease in development work at global and national levels, and integrating prevention and control of such diseases into policies across all government department; establishing and strengthening national policies and plans for the prevention and control of non-communicable disease; promoting interventions to reduce the main shared modifiable risk factors for non-communicable diseases including tobacco use, unhealthy diets, physical inactivity and harmful use of alcohol; promoting research for the prevention and control of non-communicable disease; promoting partnerships for the prevention and control of non-communicable disease; monitoring non-communicable diseases and their determinants and evaluate progress at the national, regional and global level.

Beaglehole *et al.* (2011) suggested that the top priority action for the cardiovascular disease and other non-communicable diseases is tobacco control, and proposed a goal to achieve a

world essentially free from tobacco by 2040—ie, a prevalence of less than 5%. Large countries, such as China, begin to take tobacco control seriously, rapid progress will be achieved. Some countries will set an earlier date for achievement of this goal. The other top priority intervention is salt reduction with a goal of 5 g per person per year by 2025. The Pan American Health Organization has already established a goal of 5 g by 2020. However, research data on smoking data are limited, and on salt intake are scarce. Therefore, research on cardiovascular diseases and associated research data on smoking and salt intake are needed, especially from the population in the UK.

Health risks are in transition: populations are ageing owing to successes against infectious diseases; at the same time, patterns of physical activity and food, alcohol and tobacco consumption are changing. Low-income and middle-income countries now face a double burden of increasing chronic, non-communicable conditions, as well as the communicable diseases that traditionally affect the most deprived communities. Understanding the role of these risk factors is important for developing clear and effective strategies for improving global health. Therefore, research focus on the cardiovascular health of an ageing population and different socioeconomic groups in the UK are also needed. Given that not much research has been done in people who pay for private medical insurance, priority should be given to this neglected area. Also, research data are limited on serum lipids specifically on LDL in the UK population, so more research should be needed.

Chapters 4-8 have been introduced in this literature review, except Chapter 6, which will assess the geographical variation of cardiovascular risk factors in the study population provided by the Nuffield Health. Although the prevalence of cardiovascular risk factors will be investigated at an area-level by socioeconomic status in Chapter 5, there is still a need to investigate how cardiovascular risk factors are distributed at a national geographical level, since the occurrence of cardiovascular disease does vary geographically. Other established cohort studies—The Whitehall II, Renfrew-Paisley, Scottish Heart Health, and Glasgow Students studies (Hart *et al.* 1997; Hart *et al.* 1997; Marmot *et al.* 1991; McCarron *et al.* 1999)—which conducted about two decades ago, have provided valuable aetiological insights and comparisons between women and men, but have limited national representativeness, and are unable to assess geographical variations because of their single locations. Also, although several studies have been conducted in the NHS and by public survey (Lawlor *et al.* 2003; HSE 2008; Shelton *et*

al. 2007; Shelton 2009), no study has previously been undertaken in a population of people with private medical insurance. An explanation for the regional variation remains unknown. Therefore, Chapter 6 is planned to answer this question. Therefore, the purpose of this study was to: (1) explore regional disparities in the prevalence of modifiable cardiovascular risk factors in people attending private health screenings in England; (2) compare the prevalence of modifiable cardiovascular risk factors from private medical screenings with the findings from the HSE 2006; and (3) estimate the risks of various modifiable cardiovascular risk factors at a regional level from dataset provided by the Nuffield Health.

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Appendix 3.1: Historical context for global cardiovascular disease (CVD) development (the following table is adopted from the US Institute of Medicine [IOM] 2010 report)

1992	<p>Victoria Declaration on Heart Health</p> <p>This declaration, which was issued following the First International Heart Health Conference, was intended to give a sense of urgency to the prevention and control of CVD. It focused on exploring methods of applying existing knowledge about CVD prevention on a global scale, urging government, research institutions, scientists, the media, and civil society to join forces in eliminating the CVD epidemic by adopting new policies, making regulatory changes, and implementing new population-level health promotion and CVD prevention programmes. It further specified that the policy implementation should consist of the adoption of a public health approach for the prevention and control of CVD that was inclusive of all population groups and promoted “four cornerstones” of heart health (healthy dietary habits, a tobacco-free lifestyle, regular physical activity, and a supportive psychosocial environment) (Advisory Board of the International Heart Health Conference 1992)</p>
1993	<p>The World Bank World Development Report: Investing in Health</p> <p>This report examined the interplay between human health, health policy, and economic development. Like its predecessors, this report included the World Development Indicators, which offer selected social and economic statistics on 127 countries. This report advocated a three-pronged approach to government policies for improving health in developing countries. First, governments need to foster an economic environment that enables households to improve their own health. Second, government spending on health should be redirected to more cost-effective programmes that do more to help the poor. Third, governments need to promote increased diversity and competition in the financing and delivery of health services. The report also highlighted the need to promote tobacco control and acknowledged the rising burden of chronic diseases in low-income and middle-income countries. It recommended that basic public health interventions including chronic disease prevention be part of the essential clinical package in countries with low and middle incomes (The World Bank 1993)</p>
1993	<p>Disease Control Priorities in Developing Countries (DCP)</p> <p>A comparison document to the 1993 World Development Report, this book introduced an important new metric for measurement of disease outcomes: the disability-adjusted life year (DALY). The introduction of DALYs dramatically altered the way researchers measured disease burden because it quantified the toll of disabilities associated with diseases. This development helped researchers to fully realise the tremendous burden of chronic diseases, which cause years of disability and impair an individual’s ability to lead a healthy life. The report also provided quantitative evidence on demographic transition and the resulting growth in CVD in developing countries. It also generated initial estimates of the cost-effectiveness of primary prevention, of secondary prevention (using low-cost drugs) and of treatment of angina, diabetes, and acute myocardial infarction (Jamison <i>et al.</i> 1993).</p>
1995	<p>Catalonia Declaration: Investing in Heart Health (40 case studies)</p> <p>Issued after the Second International Heart Health Conference, this declaration sought to support efforts of the Victoria Declaration by examining the economic</p>

	<p>realities of implementing CVD prevention on a global scale. It provided concrete examples of policies and programmes for CVD prevention that succeeded in saving both lives and money in an effort to prove that investment in heart health now will save money in the long term. It also provided a list of 14 recommendations for promotion of heart health, presented resources for and barriers to implementing CVD prevention programmes, and highlighted 41 successful projects that have been implemented around the world (Advisory Board of the Second International Heart Health Conference 1995).</p>
1997	<p>Catalonia Declaration Follow-up This companion document, <i>World Efforts to Improve Heart Health: A Follow-up to the Catalonia Declaration—Selected Programme Descriptions</i>, was developed to further explore case studies presented in the Catalonia Declaration and to discuss many other programmes that promote heart health. The resulting collection, which described projects in six continents and more than 30 countries, gathered diverse information under the central theme of CVD prevention. It also highlighted worldwide efforts to improve heart health and contained 83 programme descriptions, citing numerous publications and other resources (Grabowsky <i>et al.</i> 1997).</p>
1998	<p>The Singapore Declaration: Forging the Will for Heart Health in the Next Millennium This declaration, built on the Victoria and Catalonia declarations, focused on the need to build capacity to create heart health. It provided guidance on how to build capacity by developing a heart health infrastructure at international, national, and local levels; identifying leadership, policy, economic, scientific, technical, and physical aspects of this infrastructure at each level; and creating individual, organisational, and political will to carry out the implementation of an appropriate infrastructure for heart health (Pearson <i>et al.</i> 1998)</p>
1998	<p>IOM Report: Control of Cardiovascular Diseases in Developing Countries This report established priorities for research and development (R&D) investment to control CVD in developing countries and offered recommendations for R&D investment in several broad areas for the control of CVD. These areas included determining the magnitude of CVD burden in low-income and middle-income countries; developing targeted and effective prevention strategies using case-control studies; reducing tobacco use; detecting and treating hypertension; starting pilot studies to evaluate essential vascular packages of effective and low-cost drugs; developing algorithms for affordable clinical CVD care; building R&D capacity; and developing institutional mechanisms that facilitate CVD prevention and control (IOM 1998).</p>
1999	<p>World Heart Federation White Book This book was designed to define the problems posed by the present and projected burden of CVD, to document the resources available to combat these diseases, to formulate appropriate strategies for international action, and to provide a framework of action for the World Heart Federation to pursue in galvanising the energies of all the appropriate players at the global level. The book urges a global approach to CVD, emphasising coordination among global, regional, and local programmes. It also emphasised that prevention programmes must be designed to address risk factors across the entire lifespan, starting in childhood (Achutti <i>et al.</i> 1999)</p>

1999	<p>Global Strategy for the Prevention and Control of Non-Communicable Diseases: Report by the Director-General</p> <p>This report by World Health Organization (WHO) Director-General Gro Harlem Brundtland called attention to the growing burden of non-communicable diseases in low-income and middle-income countries and cited the increasingly strong epidemiological evidence linking these diseases to common risk factors. It briefly reviewed lessons learned in chronic disease prevention and control and, on the basis of these lessons, called for improved surveillance of emerging non-communicable disease epidemics and their determinants of CVD, and continued emphasis on strengthening of primary care capacity. The report became the basis for future WHO strategies for chronic disease control such as the Global Strategy on Diet, Physical Activity, and Health and the 2008 Action Plan for the Global Strategy for the Prevention and Control of Non-Communicable Diseases (Brudtland 1999)</p>
2000	<p>The 2000 Victoria Declaration</p> <p>This declaration highlighted the high burden of CVD among women worldwide, calling upon governments, research institutions, non-governmental organisations, multinational organisations, and civil society to invest resources and develop targeted CVD prevention and treatment programmes for women. While describing the policies, community action programmes, and services required to support heart disease and stroke prevention and management, the declaration emphasised using the values of “health as a human right, equity, solidarity, participation and accountability”. The declaration also emphasised the importance of the psychosocial and socioeconomic determinants of women’s heart disease and stroke (Advisory Board of the Third International Heart Health Conference 2000)</p>
2000	<p>2000 World Health Report</p> <p>The 2000 World Health Report focused on strengthening health systems. It emphasised that health systems (and their supporting governments) have four vital functions: service provision, resource generation, financing, and, most importantly, stewardship. The report stressed that it is the responsibility of national governments to ensure that health systems are providing both fair and good health care to the entire population—standards that require governments to devise essential care packages that ensure high-quality care for all. The report is significant for CVD because it is evidence of the shifting priorities of the international health community from vertical, disease-specific initiatives to a more horizontal, health-system strengthening emphasis. Furthermore, the report estimated that non-communicable diseases together contributed to almost 60% of global mortality (31.7 million deaths) and 43% of the global burden of disease in 1999 (WHO 2000a).</p>
2001	<p>The Osaka Declaration: Health Economics and Political Action: Stemming the Global Tide of Cardiovascular Disease</p> <p>This declaration furthered the process started by previous heart health declarations by reviewing the factors outside of the health sector, specifically social, economic, and political factors, that have contributed to the lack of progress in CVD prevention and promotion globally. It also argued for the crucial role that health professionals and their organisations must play in advocacy and political action to influence the governance of health systems and mitigate systemic barriers to achieving health. The declaration also went beyond</p>

	the health system to examine global forces that condition the awareness, understanding, and commitment to take global action on CVD prevention (Advisory Board of the Fourth International Heart Health Conference 2001)
2001	<p>WHO Assessment of National Capacity for Non-Communicable Disease Prevention and Control</p> <p>This report described the national capacity for non-communicable disease prevention and control in WHO member states based on a survey done in 2001. The survey found that fewer than half the WHO member states had chronic disease policies and that only about two-thirds of the countries had a chronic disease unit in their ministries of health and fewer than 40% had a specific budget line for chronic diseases. The report highlights the traditional lack of attention that chronic diseases receive in many countries around the world despite their increasing prevalence and contribution to morbidity and mortality. The report identifies several areas in which WHO could provide technical support and emphasised the need for countries and the international community to strengthen their capacity to prevent and treat chronic disease (Alwan <i>et al.</i> 2001)</p>
2002	<p>2002 World Health Report</p> <p>The 2002 World Health Report focused on reducing risks and promoting healthy lives. The report highlighted the world's ten leading risk factors that account for more than one-third of deaths worldwide. It went on to suggest effective and efficient strategies that governments and the international community can employ to reduce the prevalence of these risk factors, thus saving millions of lives. Five of the risk factors highlighted in the report—hypertension, tobacco consumption, alcohol consumption, high cholesterol, and obesity—are key cardiovascular risk factors. The report emphasised the increasing global burden of CVD, especially its rise in low-income and middle-income countries, citing the dual epidemics of infectious and non-communicable diseases that many developing countries are now facing. The report's focus on risk factor reduction and its prominent use of key CVD risk factors provides further validation of the gravity of the world CVD epidemic and signals the growing recognition from the global health community of the importance of addressing CVD in developing countries (WHO 2002a).</p>
2003	<p>Framework Convention on Tobacco Control</p> <p>This treaty, adopted by the World Health Assembly on May 21, 2003, was the first negotiated under the auspices of WHO and has since become one of the most rapidly adopted international treaties in history, having been ratified by nearly 170 countries. The treaty was developed in response to the global tobacco epidemic and represents a shift in the way the world addresses regulation of addictive substances by stressing the importance of reducing demand for tobacco. The treaty encourages countries to strengthen their tobacco control policies by enacting price, tax, regulatory, and social measures to reduce demand. The treaty represents a major milestone in the global fight to reduce chronic disease risk factors and has prompted previously unseen international collaboration around tobacco control (WHO 2003a).</p>
2003	<p>Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure</p> <p>The JNC7 report summarised the available scientific evidence on hypertension and offers guidance to primary care clinicians. The report specified</p>

	<p>hypertensive risk thresholds for adults and offered guidelines for appropriate treatment with antihypertensive medication. The report cited the significant success in awareness and reduction of hypertension in the USA, with awareness increasing by 19–70% by 1999–2000. It also reported that since 1972, age-adjusted death rates from stroke and coronary heart disease had fallen by roughly 60% and 50%, respectively. This provides evidence that CVD mortality can be significantly reduced with comprehensive treatment and prevention programmes (Chobanian <i>et al.</i> 2003)</p>
2004	<p>Towards a WHO Long-Term Strategy for Prevention and Control of Leading Chronic Diseases</p> <p>This report recommended seven strategic initiatives for action by WHO. It described the health and economic effects of chronic diseases and the long-term drivers underlying their spread, and analysed the deeply entrenched policy responses to the epidemic of chronic diseases. The resulting strategy takes a long-term, strategic global view and builds on existing research, programmes, and approaches already taken by the WHO non-communicable disease cluster (Yach and Hawkes 2004)</p>
2004	<p>WHO Global Strategy on Diet, Physical Activity, and Health</p> <p>The overall goal of this report was to promote and protect health by guiding the development of an enabling environment for substantial actions at individual, community, national, and global levels that, when taken together, will lead to reduced disease and death rates related to unhealthy diet and physical inactivity. These actions would support UN Millennium Development Goals (MDGs) and have immense potential for public health gains worldwide. The Global Strategy sought to help to reduce chronic disease risk factors stemming from poor diet and lack of physical activity through essential health action; increase overall awareness of the influences of diet and physical activity on health; encourage the development, strengthening, and implementation of policies and action plans to improve diets and increase physical activity; and monitor scientific data and support research on diet and physical activity (WHO 2004).</p>
2004	<p>The Milan Declaration: Positioning Technology to Serve Global Heart Health</p> <p>This declaration followed up on the previous International Heart Health Declarations by calling for the international community to mobilise new and existing technologies to improve heart health. The declaration examined a range of technologies—including health promotion and disease prevention, information and communication technology, food technology, medical technology, and biotechnology—and their potential to reduce the burden of CVD. Key considerations for all governments, especially those of low-income and middle-income countries, included choosing the right mix of highly technical and expensive technologies that benefit a small number of individuals and equally or less expensive population-level strategies that enhance the health status of the entire population. The declaration stressed that a comprehensive range of treatment and prevention strategies is essential to control the global CVD epidemic and that treatment technology options need to be effective but also substantial and affordable (Advisory Board of the Fifth International Heart Health Conference 2004).</p>

2004	<p>Earth Institute/IC Health Report</p> <p>This report examined the social and economic effect of CVD in one low-income and four middle-income countries, now and for the next 40 years. It also reviewed strategies for the prevention of CVD in terms of their costs and benefits, where such data exist. The report offered six conclusions emphasising the need to put CVD in low-income and middle-income countries on international health and development agendas, more accurately document the prevalence and costs of CVD worldwide, develop partnerships at the macroeconomic level with national governments in key developing countries, establish health worker training programmes about CVD, undertake trial treatment and prevention interventions, and establish a long-term research base for CVD interventions (Leeder <i>et al.</i> 2004)</p>
2005	<p>WHO Preventing Chronic Disease: A Vital Investment</p> <p>This report made the case for urgent action to halt and reverse the course of the growing chronic disease epidemic worldwide. It sought to dispel the misperception that chronic diseases are diseases of the affluent and do not affect those in low-income and middle-income countries. It estimated 80% of chronic disease-related deaths in 2005 to be in low-income and middle-income countries, and in younger people than in high-income countries. The report stressed that the growing threat of chronic diseases can be overcome using existing knowledge and highly cost-effective interventions and provided suggestions for how countries can implement interventions to reduce and prevent chronic diseases (WHO 2005a)</p>
2005	<p>2005 World Health Report</p> <p>This report highlighted maternal and child health issues. One of the major foci of the report was achieving universal access to health services, which the report stressed could be achieved through health systems strengthening. The report emphasised that this strengthening needed to occur at the infrastructure, workforce, and health system funding levels. The report also tied maternal and child health efforts to chronic diseases by recognising that the antecedents of many of these diseases occur in early life and, as such, improving health early in life is an important component of preventing the early onset of chronic diseases (WHO 2005b).</p>
2005	<p>Lancet Series on Chronic Diseases</p> <p>The first of two <i>Lancet</i> series on chronic diseases, this set of articles called attention to the major gap in the global health discourse regarding chronic diseases. The series noted that chronic diseases were not listed in the MDGs and warned that if they continue to be ignored by the global health community, the progress gained from reducing the burden of infectious disease would be eclipsed by a rising burden of chronic diseases in developing countries (Epping-Jordan <i>et al.</i> 2005; Fuster and Voute 2005; Horton 2005; Reddy <i>et al.</i> 2005; Strong <i>et al.</i> 2005; Wang <i>et al.</i> 2005).</p>
2006	<p>Disease Control Priorities in Developing Countries 2nd Edition (DDCP2)</p> <p>This follow-up to the original <i>Disease Control Priorities in Developing Countries</i> brought together 350 specialists from diverse fields and proposed context-sensitive policy recommendations to significantly reduce the burden of disease in developing countries. The book included a chapter that specifically discussed CVD and further called into focus the sizable burden of the disease in developing countries. It estimated the economic burden of CVD in low-</p>

	income and middle-income countries and updated and expanded the cost-effectiveness estimates for primary prevention, secondary prevention, and treatment interventions from the 1993 report (Jamison <i>et al.</i> 2006).
2007	<p>Lancet Series on Chronic Diseases</p> <p>The second <i>Lancet</i> series on chronic diseases noted the increasing recognition of the importance of chronic diseases within the global health community. It also provided a deeper, more complicated examination of the burden of chronic diseases and predicted the reductions in burden at the population and individual level that could be achieved through prevention and treatment interventions (Abegunde <i>et al.</i> 2007; Asaria <i>et al.</i> 2007; Beaglehole <i>et al.</i> 2007; Gaziano <i>et al.</i> 2007; Horton, 2007; Lim <i>et al.</i> 2007).</p>
2007	<p>United Nations (UN) Resolution on Diabetes</p> <p>In January, 2007, the UN established November 14 as World Diabetes Day, an official UN day. The resolution recognised diabetes as a widespread and serious chronic disease that threatens international development and the achievement of the MDGs. It also recognised that diabetes prevention and control should be included in health systems strengthening efforts. The resolution is important because it was an additional sign that the international health community was increasingly recognising the threat posed by non-communicable diseases and the necessity to invest in their prevention and control (UN General Assembly 2006).</p>
2007	<p>Grand Challenge in Chronic Non-Communicable Diseases</p> <p>This article identified the top 20 policy and research priorities for chronic non-communicable diseases. These grand challenges are intended to reduce the global epidemic of these diseases by making the case for worldwide debate, support, and funding and by guiding policy and research in an evidence-based manner. The authors asserted that with concerted action following the blueprint outlined in the article, 36 million premature deaths from chronic non-communicable diseases can be averted by 2015 (Daar <i>et al.</i> 2007).</p>
2008	<p>Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health. Final Report of the WHO Commission on Social Determinants of Health</p> <p>This report of the Commission on Social Determinants of Health examined how health-damaging experiences are unequally distributed within and across societies as a result of unfair economic arrangements, poor social policies, and discriminatory politics. The report calls on the international community to close the health gap in a generation, setting out key areas—daily living conditions, social and cultural inequalities, and the need for governments committed to equity—in which action is needed. Those social policies proven effective in improving health and health equity in countries at all levels of socioeconomic development (CSDH 2008).</p>
2008	<p>Oxford Health Alliance Sydney Resolution and Sydney Challenge (The Sydney Resolution)</p> <p>The Sydney Resolution and Challenges were the outcomes of the 2008 Oxford Health Alliance Summit and served as a call to action for the international community to make healthier choices to turn back the rising tide of preventable chronic diseases. The resolution explained that 50% of the world's deaths are caused by four preventable chronic diseases: CVD, diabetes, chronic lung disease, and cancer. The resolution stressed that these four diseases place</p>

	immense costs on society, threaten economic stability, and push individuals further into poverty. The resolution challenged the international community to take urgent action and prioritise health-promoting decisions in urban planning, food manufacturing and policy, business decisions, and public policy (The Sydney Resolution 2008).
2008	<p>The Global Burden of Disease: 2004 Update</p> <p>This update to the Global Burden of Disease report, based on 2004 data, revised previous estimates of the burden of ischaemic heart disease (IHD) and diabetes on the basis of more accurate data, resulting in a significantly increased estimate of the global burden of these chronic diseases. These revisions increased estimated DALYs attributed to IHD by 7%. The report also used new data to recalibrate the long-term case fatality rates for cerebrovascular disease, decreasing the prevalence of stroke survivors and, as a result, decreasing the estimate of global years lost to cerebrovascular disease by 30%. The report stressed that of every ten deaths globally, six are caused by chronic diseases and that CVD was the foremost cause of death in the world. CVD was responsible for 32% of global deaths in men and 27% in women in 2004. The report also affirmed that cerebrovascular disease and IHD were the number one and two causes of death in high-income and middle-income countries, and that IHD was the number two cause of death in low-income countries. Furthermore, the update projected that CVD burden would continue to increase in low-income and middle-income countries (WHO 2008b).</p>
2008	<p>WHO 2008-2013 Action Plan for the Global Strategy for the Prevention and Control of Non-Communicable Diseases</p> <p>This action plan, directed at the international development community as well as government and civil society, makes the case for urgent action to enact chronic disease prevention and control programmes. The document provides a policy framework for action, outlining a series of objectives and action items for key stakeholder groups at varying levels of the global health system. It further urges WHO Member States to develop national policy frameworks, establish prevention and control programmes, and share their experiences and build capacity internationally to address chronic diseases. Recognising that 80% of the chronic disease burden is in developing countries and that the greatest increase in disease burden over the next 10 years is projected to occur in these countries, the plan places particular focus on low-income and middle-income countries. The action plan was endorsed by all 192 Member States during the World Health Assembly in May, 2008 (WHO 2008a).</p>
2009	<p>IOM Report: The US Commitment to Global Health</p> <p>This report examined the US commitment to global health and articulated a vision for future US investments and activities. Coinciding with the US presidential transition, the report outlined how the US global health enterprise, which includes both government agencies and non-governmental organisations, can improve global health under the leadership of a new administration. The report identified five key areas for action by the US global health enterprise: scaling up existing interventions; generating and sharing knowledge to address health problems endemic to the global audience; investing in people, institutions, and capacity building with global partners; increasing the US financial commitments to global health; and setting an example of engaging in partnerships. The report also included an emphasis on the rising tide of non-</p>

	communicable diseases in low-income and middle-income countries, specifically recommending that the USA increase attention to chronic diseases and adopt a leadership role in reducing death from chronic diseases and tobacco-related illnesses (IOM 2009).
2009	<p>Kampala Statement</p> <p>This statement was a product of a summit, <i>Preparing Communities: Chronic Disease in the Developing Regions of Africa and Asia</i>, hosted by the Aga Khan Development Network, in Kampala, Uganda. In the Statement the Assembly of Kampala agreed: 1) to implement the WHO Action Plan and create the basis for a multisectoral chronic disease alliance in Asia and Africa, and to accelerate progress by sharing resources, expertise, and experiences to promote an integrated and evidence-based approach to reducing the health and economic burdens of chronic diseases; 2) that governments and multisectoral partners at all levels will provide the leadership vital to further refine and advance the directions developed during this summit; and 3) to build upon and expand the momentum generated at this summit and monitor and report back on progress in 2011 in New Delhi, India (Chronic Diseases Summit 2009).</p>
2010	<p>IOM Report: Promoting Cardiovascular Health in the Developing World: A Critical Challenge to Achieve Global Health</p> <p>The report described the parts that governments, international agencies, industries, and non-profit organisations can play in tackling the burden of heart disease in low-income and middle-income nations. Given that many developing nations have limited economic and political capacity to quickly gear up comprehensive disease reduction plans, they should in the near term prioritise steps to be effective at reducing heart disease in industrialised nations. It draws attention to strategies such as reducing tobacco use and salt in the food supply and improving the delivery of medications to patients at high risk (IOM 2010).</p>

CHAPTER 4:

PREVALENCE OF MODIFIABLE CARDIOVASCULAR RISK FACTORS BY AGE IN PEOPLE ATTENDING NUFFIELD HEALTH

ABSTRACT

Aim: This chapter aimed to examine the prevalence of various modifiable cardiovascular risk factors by age and sex for participants who accessed private health care across the UK.

Methods: A retrospective study of 65,536 participants across the UK was achieved with the use of a dataset provided by a private health-care company. Eight risk factors were analysed: body-mass index (BMI), waist size, waist-to-hip ratio (WHR), systolic and diastolic blood pressure, total cholesterol, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol. Age was divided into six groups: 18–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, and 65–75 years.

Results: For different age groups, participants aged 65–75 years had the highest prevalence of overweight and those aged 55–64 years had the highest prevalence of obesity. Participants aged 55–64 years had the second highest prevalence of overweight and those aged 45–54 years had the second highest prevalence of obesity. Participants aged 25–34 years had the highest prevalence of underweight. Participants aged 55–75 years had higher prevalence of high blood pressure.. The highest prevalences of high total cholesterol and high LDL concentrations were found in the group aged 55–64 years; and the highest prevalences of low HDL was found in the group aged 45–54 years. Women aged 65–75 years had the highest prevalence of overweight and obese. Women aged 65–75 years had the highest prevalence of high blood pressure, but women aged 18–24 years had the highest prevalence of low HDL cholesterol.

Discussion: Our data showed that male participants registered with the private medical company were likely to be overweight. Men were almost twice as likely as women to be overweight, and one in two men were overweight (as measured by BMI). Compared with prevalences previously reported in the scientific literature, participants in our study had a lower prevalence of hypertension and high total cholesterol. Men were about five times more likely

to have lower HDL than were women. Not much research evidence is available about the prevalences of LDL and WHR, with most available evidence about LDL focusing on therapeutic coverage. Our findings showed some similarity with existing studies, especially in the UK population. Our dataset is one of the largest UK datasets, especially from a commercial setting.

Conclusion: Participants aged 55–75 who attend private medical insurance need more attention paid to their cardiovascular health. They might need to care more about their lifestyle and diet, and exercise more than those from other age groups.

4.1 INTRODUCTION

In 1991, the British Government set new targets for the health of the nation, particularly for coronary heart disease and stroke, and the risk factors associated with these diseases (Secretary of State for Health 1991). After 3 years, the Health Survey for England (1994) was established to monitor trends in cardiovascular risk factors. Most cardiovascular research has focused on the general population. There has been very little research into the prevalence of cardiovascular risk factors in patients covered by private health insurance. This chapter will examine the prevalence of various cardiovascular risk factors in the population using the Nuffield Health dataset (a private medical insurance company, which provided information about nine cardiovascular risk factors): body-mass index (BMI), waist circumference, waist-to-hip ratio (WHR), systolic and diastolic blood pressure, total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and smoking. Post codes, which can be converted to deprivation score with use of the Index of Multiple Deprivation 2007, were also provided in the dataset.

Across the UK, the prevalence of obesity has rapidly increased in recent decades (DoH 2006). The number of deaths per year attributable to obesity is roughly 30,000 in the UK (Allison *et al.* 1999; Haslam and James 2005; Mokdad *et al.* 2004; National Audit Office 2001). According to Diabetes UK (2010), the number of people older than 16 years registered as obese has risen to more than 5.5 million in 2010—an increase of more than 265,000 compared with the previous year. One in ten of the population is being treated for obesity. The condition costs the National Health Service (NHS) an estimated £4.2 billion annually, which will more than double by 2050 (QOF 2010).

High blood pressure is the leading cause of cardiovascular death in all regions, contributing to 37% of cardiovascular deaths in regions of southeast Asia (eg, India), and to 54% of cardiovascular deaths in middle-income European countries (Danaei *et al.* 2006). Average blood pressure levels are particularly high in middle-income European countries and African countries, mainly due to poor diet, alcohol consumption, lack of exercise, and obesity; these effects accumulate with age (WHO 2002; WHO 2005a).

The first nationwide survey of the management of hypertension in England, using data from the Health Survey for England 1994, of adults aged 16 years and older, reported that 19.5% were hypertensive (defined as systolic blood pressure ≥ 160 mm Hg, diastolic blood pressure ≥ 95 mm Hg, or anti-hypertensive treatment). Among patients with hypertension, only 66% of women and 60% of men had been told they had high blood pressure previously. Approximately half of all patients with hypertension were receiving treatment (54.4% of women vs. 44.8% of men), and of these patients, 59% of patients achieved adequate control of blood pressure (defined as blood pressure $< 160/95$ mm Hg). On the basis of a more stringent definition of hypertension (systolic blood pressure ≥ 140 mm Hg, or diastolic blood pressure ≥ 90 mm Hg) (Kaplan *et al.* 2003), the analogous rates for awareness, treatment, and control were 40%, 26%, and 6%, respectively (Colhoun *et al.* 1998). However, although rates of awareness, treatment, and control have improved, most patients with hypertension still achieve inadequate control of blood pressure or receive no anti-hypertensive treatment at all (Burt *et al.* 1995; Colhoun *et al.* 1998).

Trends in hypertension prevalence in the USA have, in general, been obtained from the National Health and Nutrition Examination Survey (NHANES). NHANES is a sequential stratified multistage probability sample of adults and children in the USA. The first survey was conducted in 1960–1962 and the latest in 1999–2002. The age-adjusted prevalence of hypertension fell between 1960–1962 and 1988–1991, from 29.7% to 20.4% (Burt *et al.* 1995). On the basis of NHANES data, in 1991–1994, the age-adjusted prevalence of hypertension was 25%, and in 1999–2002 was 28.6% (Hajjar and Kotchen 2003). Hypertension affects approximately one in three adults in the USA. Every year, hypertension contributes to one of every seven deaths in the USA and to nearly half of all cardiovascular-disease-related mortality, including stroke (Chobanian *et al.* 2003). Data from the Framingham Heart Study suggest that cardiovascular disease risk is increased by 2.5 times in women and 1.6 times in men with systolic blood pressure between 130–139 mm Hg and diastolic blood pressure 85–89 mm Hg (Kannel 1996; Vasan *et al.* 2001). The UK Public Health Observatory's modelling study estimated that the number of people with high blood pressure increased by 2.7% per year from 332,767 in 2004/2005 to more than 12 million in 2007/2008. During the same period, figures from the Quality Framework statistics showed that general practitioners discovered and diagnosed 934,993 people with high blood pressure. This finding increased the number of

people diagnosed with high blood pressure to about 7 million. 5.7 million people in the UK are at risk without knowing it.

Overall, raised total cholesterol is estimated to cause 2.6 million deaths and 29.7 million disability-adjusted life-years (WHO 2009) worldwide. In 2008, the global prevalence of raised total cholesterol among adults was 39% (37% in men and 40% in women). According to the WHO report on non-communicable diseases (2011), the prevalence of elevated total cholesterol was highest in the WHO Region of Europe (54% for both sexes), followed by the WHO Region of the Americas, which the prevalence was 48% for both sexes. The WHO African Region and the South East Asian Region showed the lowest rate, which were 22.6% and 29.0%. The prevalence of raised total cholesterol increased substantially on the basis of country's income level. In low-income countries, about 15% of adults had raised total cholesterol, increasing to more than 30% in low-income and middle-income countries. In high-income countries, more than 50% of adults had raised total cholesterol, more than three times as many as in low-income countries (WHO 2011).

Cholesterol increases the risks of heart disease, stroke, and other vascular diseases. Recent research shows that concentrations of LDL and HDL cholesterol are more important for health than is total cholesterol (ALLHAT Collaborative Research Group 2002; Lewington *et al.* 2007). Findings from some randomised controlled trials also suggested that larger reductions in LDL cholesterol would produce larger reductions in the risk of cardiovascular events (Chen *et al.* 1991; Cholesterol Treatment Trialists' Collaboration 2005; Heart Protection Study Collaborative Group 2002; Stamler *et al.* 1993). The evidence-based recommendations for management of lipid disorders in clinical practice in the USA are specified by the National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III) (Grundy 2001). The NCEP ATP III places a primary focus for cholesterol management on high concentrations of LDL cholesterol. The guidelines set LDL target concentrations that are based on history of coronary heart disease (CHD) or risk for developing CHD in the next 10 years. Kuklina and colleagues (2009), using the National Health and Nutrition Examination Survey (NHANES) data, investigated trends of LDL prevalence across 4 study cycles (1999–2000, 2001–2002, 2003–2004, and 2005–2006), reported that, among the NHANES population aged 20 years or older, the prevalence of high LDL concentrations decreased from 1999–2000 to 2005–2006, and in the most recent period, the prevalence of high LDL was 21.2%.

Much research about risk factors for cardiovascular disease has been undertaken in the NHS in the UK (Marmot 1985; Lyratzopoulos *et al.* 2006; Purslow *et al.* 2008). However, according to figures from the Association of British Insurers (2009), the number of people covered by private medical insurance rose to more than 6 million in 2008—about 10% of the UK's population—and included an increasing number of people employed in all sectors of the workforce from manual to management. However, little evidence has been gathered in this affluent population. In Chapter 1 (Introduction), I have explained the reason why this research is urgently needed. Therefore, this chapter aims to examine the prevalence by age of various modifiable cardiovascular risk factors in this affluent population, and compare the results with the general population represented in Health Survey for England 2006.

4.2 DESIGN AND METHODS

4.2.1 Study setting and data collection

Data were provided by a private health-care company, Nuffield Health. Identification of individuals is not possible from these data, because they are provided by a unique patient reference number in a dataset. The assessment programmes were delivered through a bespoke electronic patient-record system developed exclusively for Nuffield Health, the Vi System. This system offers greater accuracy and speedier and more comprehensive reports than other systems (eg, paper-based systems). It has four interventions—Vi₃, Vi₄, Vi₅, and Vi₆. It provides instant comparison with previous test results and the ability for clients to use any of their centres in the UK and immediately access the records. Data were extracted from the records of the Nuffield Health. Aggregate data provided by the Nuffield Health were anonymised, in line with the Information Commissioner Office's (2013) anonymisation code; it can be freely processed and publicly disclosed. Data were recorded for participants during screening for provision of employment-related medical care. At each of the company's testing sites, data were collected by trained health professionals using protocols consistent with the British Hypertension Society (for blood pressure and blood analysis) and American College of Sports Medicine (for anthropometry).

4.2.2 Cardiovascular risk factors

Several established cardiovascular risk factors represent the risk profile of the participants: (1) anthropometric characteristics; (2) blood pressure; and (3) plasma serum. BMI, WHR, and waist circumference were examined. BMI is defined as: (1) underweight ($<18.5 \text{ kg/m}^2$); (2) normal ($18.5\text{--}<25 \text{ kg/m}^2$); (3) overweight ($25\text{--}<30 \text{ kg/m}^2$); (4) obese ($30\text{--}<40 \text{ kg/m}^2$); or (5) morbidly obese ($>40 \text{ kg/m}^2$; HSE 2008). Waist circumference was measured at the anatomical waist. For men, low waist circumference was defined as less than 94 cm, high as 94–102 cm, and very high as greater than 102 cm; for women, low waist circumference was less than 80 cm, high was 80–88 cm, and very high was greater than 88 cm (NICE 2006a). WHR was calculated and defined as high if values were greater than 0.95 in men and greater than 0.80 in women (Croft *et al.* 1995). Blood pressure included systolic blood pressure and diastolic blood pressure. All blood pressure measurements were taken after the participant completed a Nuffield Health questionnaire, which typically took 10–12 min. Blood pressure was measured after a further 5 min of quiet, seated rest. Trained staff fitted an appropriately sized inflatable cuff around the upper left arm of each participant. Participants were instructed to sit still in their chair with their left arm resting on a table at the same level as the heart. One measure of systolic blood pressure and diastolic blood pressure was made with an aneroid sphygmomanometer (Welch Allyn DS45; Skaneateles Falls, New York, NY, USA). Hypertension was classified as greater than 90 mm Hg (diastolic) and greater than 140 mm Hg (systolic; NICE 2006b). Plasma serum included total, HDL, and LDL cholesterol. For Vi₄, the finger prick method was used (Accutrend GC; Roche Diagnostics, Mannheim, Germany); for Vi₃, Vi₅, and Vi₆, the venous method was used, and the blood sample was drawn and analysed (poch100i; Sysmex, Kobe, Japan). Total cholesterol was classified as raised if higher than 6 mmol/L. HDL was classified as low if less than 1.0 mmol/L; LDL was defined as raised if greater than 3.36 mmol/L (Contois *et al.* 1996). Age was divided into six groups: 18–24, 25–34, 35–44, 45–54, 55–64, and 65–75 years.

4.2.3 Statistical analysis

Data from this study were analysed with SPSS version 17.0 (SPSS Inc, Chicago, IL, USA). The dependent measures were modifiable risk factors—eg, BMI, WHR, waist circumference,

blood pressure, plasma cholesterol, etc. Prevalence was calculated for each modifiable risk factor proportionately.

4.3 RESULTS

Table 4.1 shows the prevalence of modifiable cardiovascular risk factors in different age groups of the overall population. Tables 4.2 and 4.3 show the prevalence of modifiable cardiovascular risk factors in different age groups for men and women, respectively. The data show a normal distribution pattern, with the mean about age group 35–44 years old.

Table 4.1: Prevalence of modifiable cardiovascular risk factors in different age groups

	Group 1, age 18– 24 years	Group 2, age 25–34 years	Group 3, age 35–44 years	Group 4, age 45–54 years	Group 5, age 55–64 years	Group 6, age 65–75 years	Total
Body-mass index (n)	1427	11154	18628	17600	9424	1583	59816
Underweight (n)	49	229	124	92	46	8	548
%	3.4%	2.1%	0.7%	0.5%	0.5%	0.5%	1.0%
Normal (n)	983	6485	7814	6223	2905	524	24934
%	68.9%	58.0%	41.9%	35.4%	30.8%	33.1%	41.7%
Overweight (n)	305	3478	7765	7908	4532	808	24796
%	21.4%	31.2%	41.7%	44.9%	48.1%	51.0%	41.4%
Obese (n)	80	917	2785	3216	1859	234	9091
%	5.6%	8.2%	15.0%	18.3%	19.7%	14.8%	15.2%
Morbidly obese (n)	10	45	140	161	82	9	447
%	0.7%	0.4%	0.8%	0.9%	0.9%	0.6%	0.7%
Waist circumference (n)	1182	9879	17455	16612	8985	1512	55625
High (n)	135	1483	4053	4316	2631	459	13077
%	11.4%	15.0%	23.2%	26.0%	29.3%	30.4%	23.5%
Very high (n)	87	1011	3119	3946	2514	436	11113
%	7.4%	10.2%	17.9%	23.8%	28.0%	28.8%	20.0%
Waist-to-hip ratio (n)	1182	9879	17455	16610	8985	1512	55623
n	159	1440	3973	5135	3542	702	14951
%	13.5%	14.6%	22.8%	30.9%	39.4%	46.4%	26.9%
Systolic blood pressure (n)	1426	11153	18623	17598	9423	1583	59806
n	31	325	1198	2132	2090	515	6291
%	2.2%	2.9%	6.4%	12.1%	22.2%	32.5%	13.1%
Diastolic blood pressure (n)	1426	11153	18625	17598	9423	1583	59808
n	25	345	1485	2179	1420	205	5659
%	1.8%	3.1%	8.0%	12.4%	15.1%	13.0%	9.5%
Total cholesterol (n)	668	6400	14880	16333	8979	1539	48799
n	132	2046	7583	10749	6287	993	27790
%	19.8%	32.0%	51.0%	65.8%	70.0%	64.5%	57.0%
High-density lipoprotein (n)	668	6400	14875	16329	8978	1539	48789
n	43	482	1588	1775	954	138	4980
%	6.4%	7.5%	10.7%	10.9%	10.6%	9.0%	10.2%
Low-density lipoprotein (n)	669	6351	14619	16024	8860	1525	48048
n	66	1118	5077	7538	4534	742	19075
%	9.9%	17.6%	34.7%	47.0%	51.2%	48.7%	40.0%

Table 4.2: Prevalence of modifiable cardiovascular risk factors in different age groups in men

	Group 1, age 18– 24 years	Group 2, age 25– 34 years	Group 3, age 35– 44 years	Group 4, age 45– 54 years	Group 5, age 55–64 years	Group 6, age 65–75 years	Total
Body-mass index (n)	633	5592	11381	11423	6525	1048	36602
Underweight (n)	12	34	22	10	6	2	86
%	1.9%	0.6%	0.2%	0.1%	0.1%	0.2%	0.2%
Normal (n)	398	2666	3583	2995	1575	292	11509
%	62.8%	47.7%	31.5%	26.2%	24.1%	27.9%	31.4%
Overweight (n)	179	2353	5722	6060	3513	604	18431
%	28.3%	42.1%	50.3%	53.1%	53.8%	57.6%	50.3%
Obese (n)	40	520	1984	2285	1389	144	6362
%	6.3%	9.3%	17.4%	20.0%	21.3%	13.7%	17.4%
Morbidly obese (n)	4	19	70	73	42	6	214
%	0.6%	0.3%	0.6%	0.6%	0.6%	0.6%	0.6%
Waist circumference (n)	633	5595	11376	11425	6522	1047	36598
High (n)	58	838	2704	3210	2021	327	9158
%	9.2%	15.0%	23.8%	28.1%	30.1%	31.2%	25.0%
Very high (n)	35	470	1862	2487	1706	268	6828
%	5.5%	8.4%	16.4%	21.8%	26.2%	25.6%	18.6%
Waist-to-hip ratio (n)	633	5595	11376	11425	6522	1047	36598
n	18	338	1593	2661	2160	392	7162
%	2.8%	6.0%	14.0%	23.3%	33.1%	37.4%	19.6%
Systolic blood pressure (n)	632	5593	11377	11422	6523	1048	36595
n	24	276	986	1604	1580	325	4795
%	3.8%	4.9%	8.7%	14.0%	39.6%	33.9%	13.1%
Diastolic blood pressure (n)	632	5593	11377	11422	6523	1048	36595
n	18	280	1229	1738	1148	141	4554
%	2.8%	5.0%	10.8%	15.2%	17.6%	13.5%	12.4%
Total cholesterol (n)	180	2784	8840	10526	6211	1018	29559
n	33	1091	5276	7230	4097	597	18324
%	18.3%	39.2%	59.7%	68.7%	66.0%	58.6%	62.0%
High-density lipoprotein (n)	180	2784	8836	10522	6210	1018	29550
n	25	377	1395	1594	894	124	4409
%	13.9%	13.5%	15.8%	24.7%	14.4%	12.2%	15.0%
Low-density lipoprotein (n)	181	2740	8594	10245	6101	1004	28865
n	26	736	3911	5469	3078	452	13672
%	14.4%	26.9%	45.5%	53.4%	50.5%	45.0%	47.4%

Table 4.3: Prevalence of modifiable cardiovascular risk factors in different age groups in women

	Group 1, age 18–24 years	Group 2, age 25–34 years	Group 3, age 35–44 years	Group 4, age 45–54 years	Group 5, age 55–64 years	Group 6, age 65–75 years	Total
Body-mass index (n)	794	5562	7247	6177	2899	535	23214
Underweight (n)	37	195	102	82	40	6	462
%	4.7%	3.5%	1.4%	1.3%	1.4%	1.3%	2.0%
Normal (n)	585	3819	4231	3228	1330	232	13425
%	73.7%	68.7%	58.4%	52.3%	45.9%	43.4%	57.8%
Overweight (n)	126	1125	2043	1848	1019	204	6365
%	15.9%	20.2%	28.2%	29.9%	35.2%	38.1%	27.4%
Obese (n)	40	397	801	931	470	90	2729
%	5.0%	14.5%	11.1%	15.1%	16.2%	16.8%	11.7%
Morbidly obese (n)	6	26	70	88	40	3	233
%	0.8%	0.5%	1.0%	1.4%	1.4%	0.6%	1.0%
Waist circumference (n)	549	4284	6079	5187	2463	465	19027
High (n)	77	645	1349	1106	610	132	3919
%	14.0%	15.1%	22.2%	21.3%	24.8%	28.4%	20.6%
Very high (n)	52	541	1257	1459	808	168	4285
%	9.0%	12.6%	20.7%	28.1%	32.8%	36.1%	22.5%
Waist-to-hip ratio (n)	549	4284	6079	5185	2463	465	19025
n	141	1102	2380	2474	1382	310	7789
%	25.7%	25.7%	39.2%	47.7%	56.1%	66.7%	41.0%
Systolic blood pressure (n)	794	5560	7246	6176	2900	535	23211
n	7	49	212	528	510	190	1496
%	0.9%	0.9%	2.9%	8.5%	17.6%	35.5%	6.4%
Diastolic blood pressure (n)	794	5560	7248	6176	2900	535	23213
n	7	65	256	441	272	64	1105
%	0.9%	1.2%	3.7%	7.1%	9.4%	12.0%	4.8%
Total cholesterol (n)	488	3616	6040	5807	2768	521	19240
n	99	955	2307	3519	2190	396	9466
%	20.3%	26.4%	38.2%	60.6%	82.7%	76.0%	49.2%
High-density lipoprotein (n)	488	3616	6039	5807	2768	521	19239
n	18	105	193	181	60	14	571
%	3.7%	2.9%	3.2%	3.2%	2.2%	2.7%	3.0%
Low-density lipoprotein (n)	488	3611	6025	5779	2759	521	19183
n	40	382	1166	2069	1456	290	5403
%	8.2%	10.6%	19.4%	35.8%	52.8%	55.7%	28.2%

4.3.1 Adiposity

4.3.1.1 Body-mass index

In the overall population (table 4.1), participants aged 65-75 years (group 6) had the highest prevalence of overweight. The highest prevalence of obesity occurred in group 5 (ages 55-64 years) and of morbid obesity in both group 5 and 4 (ages 55-64 and 45-54). The second highest prevalence of overweight, obesity, and morbid obesity occurred in group 5 (ages 55-64), 4 (ages 45-54) and 3 (35-44), respectively. Participants aged 25-34 years (group 2) had the highest prevalence of underweight.

For men (table 4.2), group 6 (ages 65-75 years) had the largest number of participants that were overweight ($n=604$). Men aged 55-64 years (group 5) had the highest prevalence of obesity ($n=1389$). Morbid obesity occurred in the same percentage (0.6%) in all groups except group 2 (ages 25-34 years) where it was the lowest and equaled 0.3%. Group 2 (ages 25-34 years) had the largest number of participants that were underweight ($n=34$). Men shared similar pattern as the overall population; the highest prevalence of overweight and obesity was found in group 6 (ages 65-75 years) and 5 (ages 55-64 years) and equaled 57.6% and 21.3%, respectively. Men aged 18-24 years (group 1) had the highest prevalence of underweight (1.9%) and the lowest prevalence of overweight (28.3%) and obesity (6.3%). The second-lowest prevalence of overweight and obesity was found in group 2 (ages 25-34 years) and equaled 42.1% and 9.3%, respectively. For women (table 4.3), group 5 (ages 55-64 years) had the largest number of participants that were overweight ($n=2043$); group 4 (ages 45-54 years) had the largest number of participants that were obese and morbidly obese ($n=931$ and 88, respectively). The highest prevalence of overweight and obesity was found in group 6 (ages 65-75 years) and equaled 38.1% and 16.8%, respectively. The highest prevalence of morbid obesity occurred in both group 4 (ages 45-54 years) and 5 (ages 55-64 years) and equaled 1.4%. The highest prevalence of underweight was found in group 1 (ages 18-24) and equaled 4.7%. Women shared the same pattern as men in the lowest prevalence of overweight, obesity, and morbid obesity between 18-24 years and 65-75 years. The second-lowest prevalence of overweight was found in group 2 (ages 25-34 years) and the second-lowest prevalence of obesity was found in group 3 (35-44 years) and equaled 20.2% and 11.1%, respectively.

4.3.1.2 Waist circumference

In the overall population (table 4.1), participants aged 65-75 (group 6) had the highest prevalence of high and very high waist circumference (30.4% and 28.8%, respectively).

For men (table 4.2), group 4 had the largest number of participants that were centrally obese (high: n=3210; very high: n=2487). The highest prevalence of high waist circumference (31.2%) was found in group 6 (ages 65-75 years). The highest prevalence of very high waist circumference (26.2%) was found in group 5 (ages 55-64 years). The lowest prevalence of central obesity (both high and very high) was found in group 1 (ages 18–24 years); the figures were 9.2% and 5.5%, respectively. For women (table 4.3), group 3 had the largest number of participants that had high waist circumference (n=1349), and group 4 had the largest number of participants that had very high waist circumference (n=1459). The prevalences in these two groups were 22.4% (high) and 28.1% (very high), respectively. The highest prevalence of both high and very high waist circumference occurred in group 6 and equaled 28.4% and 36.1%, respectively. The lowest prevalence of high and very high waist circumference were also found in group 1, and the figures were 14.0% and 9.0%, respectively.

4.3.1.3 Waist-to-hip ratio (WHR)

In the overall population (table 4.1), participants aged 65-75 (group 6) had the highest prevalence of higher WHR (46.4%).

Women (table 4.3) were more than twice as likely as men (table 4.2) to have a higher prevalence of higher WHR; the rate was 19.6% in men and 41.0% in women. For both men and women, the highest prevalence of higher WHR was found in group 6 (37.4% and 66.7%, respectively); the lowest prevalence was found in group 1 (ages 18–24 years; 2.8% and 25.7%, respectively). The prevalence of WHR equaled 25.7% in women aged 25-34 years as well. The second highest prevalence of higher WHR was found in group 5 (ages 55–64 years) for both men and women and equaled 33.1% and 56.1%, respectively.

4.3.2 Blood pressure

4.3.2.1 Systolic blood pressure

In the overall population (table 4.1), participants aged 65-75 years (group 6) had the highest prevalence of high systolic blood pressure; those aged 55-64 (group 5) years had the second highest prevalence of high systolic blood pressure. Participants aged 18-24 years (group 1) had the lowest prevalence of high systolic blood pressure.

Men (table 4.2) were about twice as likely to have higher prevalence of higher systolic blood pressure as were women (table 4.3). The figures were 13.1% in men and 6.4% in women. In men, the highest prevalence of higher systolic blood pressure equaled 39.6% and was found in group 5 (ages 55-64 years). In women, it equaled 35.5% and occurred in group 6 (ages 65-75 years). The second highest prevalence of higher systolic blood pressure was found in group 6 in men (33.9%) and in group 5 in women (17.6%). The lowest prevalence in men was 3.8% and was found in group 1 (ages 18-24). In women, both group 1 and group 2 had the lowest prevalence of 0.9%.

4.3.2.2 Diastolic blood pressure

In the overall population (table 4.1), participants aged 55-64 years (group 5) had the highest prevalence of high diastolic blood pressure; those aged 65-75 years (group 6) had the second highest prevalence of high diastolic blood pressure. Participants aged 18-24 years (group 1) had the lowest prevalence of high diastolic blood pressure.

The prevalence of high diastolic blood pressure shared similar pattern as did systolic blood pressure in men (table 4.2) and women (table 4.3). The figures were 12.4% in men and 4.8% in women, respectively. In men, the highest prevalence of 17.6% was found in group 5 (ages 55-64 years) and the second highest prevalence of 15.2% was found in group 4 (ages 45-54 years). In women, the highest prevalence was 35.5% and occurred in group 6 (ages 65-75 years) and the second highest prevalence was 17.6% and was found in group 5 (ages 55-64

years). The lowest prevalence occurred in group 1 in men and group 1 and 2 in women and equaled 2·8% and 0·9%, respectively.

4.3.3 Serum lipids

4.3.3.1 Total cholesterol

Highest prevalence of high total cholesterol was found in group 5 (ages 55-64 years); and the second highest prevalence was found in group 4 (ages 45-54 years). The lowest prevalence was found in group 1 (ages 18-24 years) (table 4.1).

The prevalence of high total cholesterol in men (table 4.2) and women (table 4.3) was 62·0% and 49·2%, respectively. For men, the highest prevalence was 68·7% and was found in group 4 (ages 45-54 years) and the second highest prevalence equaled 66·0% and occurred in group 5 (ages 55-64 years). For women, the highest prevalence was 82·7% and was found in group 5 and the second highest prevalence equaled 76·0% and was found in group 6 (ages 65-75 years). The lowest prevalence of high total cholesterol in both men and women was found in group 1 (ages 18-24) and equaled 18·3% and 20·3%, respectively.

4.3.3.2 High-density lipoprotein cholesterol

The highest prevalence of low HDL was found in group 4 (ages 45-54 years); and the second highest prevalence was found in group 5 (ages 55-64 years). The lowest prevalence of low HDL was found in group 1 (ages 18-24 years) (table 4.1).

Men were about five times more likely to have higher prevalence of lower HDL than in women. The prevalence of low HDL was 15·0% and 3·0% in men and women, respectively (tables 4.2 and 4.3). For men, the highest prevalence of 24·7% was found in group 4 (ages 45-54 years) and the second highest prevalence of 15·8% in group 3 (ages 35-44 years). For women, the highest prevalence of 3·7% occurred in group 1 (ages 18-24 years) and the second highest prevalence of 3·2% was found in both group 3 and 4. The lowest prevalence in men was found in group 6 and equaled 12·2% and in women was found in group 5 and equaled 2·2%.

4.3.3.3 Low-density lipoprotein cholesterol

Highest prevalence of high LDL was found in group 5 (ages 55-64 years); and the second highest prevalence was found in group 6 (ages 65-75 years). The lowest prevalence was found in group 1 (ages 18–24 years) (table 4.1).

The prevalence of high LDL in men (table 4.2) and women (table 4.3) was 47·4% and 28·2%, respectively. For men, the highest prevalence of high LDL was found in group 4 and equaled 53·4%. The second highest prevalence of 50·5% occurred in group 5 (ages 55-64 years). For women, the highest prevalence was 55·7% and was found in group 6 (ages 65-75 years) and the second highest prevalence was 52·8% and occurred in group 5. The lowest prevalence for both men and women was found in group 1 (ages 18-25 years) and equaled 14·4% and 8·2%, respectively.

4.4 DISCUSSION

4.4.1 Overall findings of this study

The prevalence of various modifiable cardiovascular risk factors—BMI, WHR, waist circumference, systolic blood pressure, diastolic blood pressure, total cholesterol, HDL, and LDL—for clients who attended health centres across the UK were analysed from a substantial dataset. Overall, participants in group 6 (ages 65–75 years) had the highest prevalence of overweight, participants in group 5 (ages 55–64 years) had the highest prevalence of obesity. Participants in group 6 had the highest prevalence of high systolic blood pressure and participants in group 5 had the highest prevalence of high diastolic blood pressure. Participants in group 5 had the highest prevalence of high total cholesterol and LDL; participants in group 4 (ages 45-54 years) had the highest prevalence of low HDL. Men in group 6 had the highest prevalence of overweight, but men in group 5 had the highest prevalence of obesity; women in group 6 had the highest prevalence of both overweight and obesity. Men in group 5 and women in group 6 had the highest prevalence of high systolic and diastolic blood pressures. Men in group 4 had the highest prevalence of high total cholesterol and LDL, as well as low HDL;

whereas women in group 5 had the highest prevalence of high total cholesterol, group 6 had the highest prevalence of high LDL, and group 1 (ages 18-24 years) had the highest prevalence of low HDL.

4.4.2 Obesity

WHO describes obesity as one of the most neglected public health problems in both developing and developed countries. Globally, it was estimated by WHO (2008a) that more than 1 billion adults 20 years or older were overweight ($\text{BMI} \geq 25 \text{ kg/m}^2$) and more than 500 million were obese in 2008 ($\text{BMI} \geq 30 \text{ kg/m}^2$). Overweight and obesity are increasing worldwide with changes in lifestyle such as diet and physical inactivity (Bull *et al.* 2004; Lock *et al.* 2004). In my study, BMI, waist circumference, and WHR will be considered together because patterns are similar, but individual variables will be discussed and compared with the Health Survey for England 2006 separately.

The recent European Health Interview Survey (EHIS 2011) published by Eurostat—the statistical office of the European Union, aims to measure the health status, life style and health care of citizens across the European Union Member States on a harmonised basis. Obesity and overweight was measured using BMI. Among the 19 member states, the proportion of obese people in the adult population varied in 2008/2009 between 8.0% and 23.9% for women and between 7.6% and 24.7% for men. According to the report, the UK's prevalence of obesity was highest in men aged 45–64 years, and in women aged 65–74 years; the figures were 31.1% and 33.2%, respectively. Men aged 45–64 had higher prevalence of obesity in this study, and the figure was 41.3%. This finding is higher than that of the EHIS study. Meanwhile, women aged 65–74 had the second lowest prevalence of obesity in this study, with a figure of 16.8%. However, women who had the highest prevalence of obesity was aged 55–64 years, with a figure of 46.1%. The prevalence of obesity in both men and women aged 18–24 years was the lowest, but was almost three times higher for women than for men (5.9% vs. 16.6%). This finding is very similar to my finding, which showed that the prevalence of obesity in both men and women aged 18–24 years was the lowest (6.3% vs. 5.0%).

In Canada, obesity has emerged as a critical public health issue during the past few decades. The Canadian Community Health Survey 2004 (CIHI 2006) showed that about 36% of Canadian adults were overweight, and almost 23% could be recognised as obese. In the USA, the prevalence of obesity was 26·8% for women and 27·6% for men in 2009 (Pleis *et al.* 2010). A study of the prevalence of obesity in urban Delhi has been completed by the Nutrition Foundation of India. It has reported that the prevalences of overweight (BMI ≥ 25 kg/m²) and obesity (BMI >30 kg/m²) were 50% and 14%, respectively (Gopalan 1998). However, this was in contrast to my findings—the prevalences of overweight and obesity in the overall population were 41·4% and 15·2%. The prevalence of obesity was 11·7% for women and 17·4% for men. It seems that the rate of overweight in my study is higher than in other developed countries such as Canada, but lower than in developing countries such as India. The rate of obesity is lower in my study than other developed countries such as the USA, but higher than other developing countries such as India. This finding could result from the fact that the population in my study was more affluent than the general UK population and could afford private medical insurance; the prevalence of obesity in men and women in the general UK population is 22·1% and 23·9%, respectively (EHIS 2011).

Our findings were different from Health Survey for England 2006 (2008). In this survey, the prevalences of overweight and obesity, which was measured by BMI, were 43% and 24% in men, and 32% and 24% in women. The current research showed that the prevalences of overweight and obesity were 50·3% and 17·4% in men, and 27·4% and 11·7% in women. In the present research, men seemed more likely to be overweight but less likely to be obese than were those in Health Survey for England; women were less likely to be overweight and obese. Also, in the Health Survey for England 2006, men were more likely to be overweight than were women in all age groups, and were more likely to be obese than were women aged less than 65 years. However, they were less likely to be obese than were women aged 65 years and older. There were some similarities between this research and the Health Survey for England 2006—men were more likely to be overweight than were women aged 18 years and older, but results were not consistent in men and women who were obese. Also, in a systematic review of the evidence for diagnosis and treatment of obesity in older adults, McTigue *et al.* (2006) found that obesity could be diagnosed easily and inexpensively using an anthropometric measure. BMI might have the greatest clinical utility because it is linked with the widest range of health

states, and waist circumference and WHR might be useful adjuncts for assessing cardiovascular risk in adults who were aged 60 years and older.

In the Health Survey for England 2006 (2008), the prevalence of raised waist circumference, which was defined as to be greater than 102 cm in men and greater than 88 cm in women, was 32% in men and 41% in women. In the current research, the figures for men and women were 18.6% and 22.5%, respectively. Compared with the population in the Health Survey for England 2006, men and women were shown to be less obese in the current research findings. According to the data from Health Survey for England 2006, women were more likely to have raised waist circumference than men. Men and women shared the same pattern in all age groups, in which their raised waist circumference went up with the increase of their age up to 75 years, but suddenly going lower aged 75 years and older. In the current research, women were also more likely to have a raised circumference than men aged less than 35 years, but less likely aged 35 years and older. The similar pattern of prevalence in men and women which showed the raised waist circumference was going up with the increase of age less than 45 years, and going down with the decrease of age at 45 years and older.

Overall, men and women in the current research were shown to be healthier in terms of adiposity than the population from the Health Survey for England 2006. One reason could be because people who attended private medical screening were from least deprived groups, and they were wealthier and healthier. In a recent report of eating habits in 19 European Union countries published by the European Food Information Council (2011), it was suggested that the British were not eating enough fruit and vegetables. The analysis showed that the British ate 258g (9.1oz) of fruit and vegetables a day, compared with a European average of 386g (13.6oz), and even lower than 400g (14.1oz) minimum consumption recommended by WHO. People from the most deprived groups may not be able to afford enough fruit and vegetables compared with those from the least deprived groups (Dibsdall *et al.* 2003). High costs might negatively affect intake on fruit and vegetables, especially in the most deprived groups. Thus, affordability, availability, and accessibility are likely to be several factors mediating the effect of socioeconomic groups on fruit and vegetable consumption (Kamphuis *et al.* 2007; WHO 2005b). Therefore, further research into the association between socioeconomic groups and obesity is needed.

Many dietary interventions encourage participants to eat less fat and more fruit and vegetables, restrict their dietary sodium intake to less than 6 g per day, avoid processed food with high salt content, add less salt to food or substitute low-sodium salt, and take regular aerobic exercise for at least 30 min three to five times a week. Overweight patients should be encouraged to lose weight through a low-calorie diet and exercise. Clinicians should ascertain their patients' alcohol consumption and recommend reduced intake if patients drink excessively. It might be more appropriate to recommend inclusion of oily fish in a healthy diet rather than fish oil supplements (Kris-Etherton *et al.* 2002).

BMI has been routinely used in clinical and public health practice for decades to identify individuals and populations at risk of future cardiovascular disease. However, in recent years, BMI has been criticised as a measure of risk because it reflects both fat and lean mass and because it does not identify fat distribution (Mason *et al.* 2008). A growing body of evidence suggests that abdominal adiposity is a more important risk factor for cardiovascular disease than is general adiposity (Janssen *et al.* 2004). The mechanisms through which abdominal fat contributes to the risk of these diseases are not fully understood, although one of the components of abdominal fat—visceral adipose tissue, which is highly metabolically active—is believed to play a key part (Despres 2006).

Several studies have recommended the use of anthropometric measures that capture abdominal adiposity, such as waist circumference and WHR, as alternatives to, or in addition to, BMI in assessment of disease prediction in clinical practice and public health surveillance (Dobbelsteyn *et al.* 2001; Pischon *et al.* 2008; Yusuf *et al.* 2005). There are, however, concerns about the reliability of these measurements (Sebo *et al.* 2008), because waist and hip circumference can differ depending on the precise site at which they are measured (Wang *et al.* 2003). Results from published studies to date that have tried to compare different measurements of general and regional adiposity have not been consistent. BMI has been compared separately with different anthropometric measures, and different outcome measures have been assessed (Canoy *et al.* 2006; Pischon *et al.* 2008; Vazquez *et al.* 2007; Wannamethee *et al.* 2005). This is why several measures were used including BMI, WHR and waist circumference, to assess adiposity in the study.

4.4.3 Blood pressure

Men in group 5 (ages 55–64 years) and women in group 6 (ages 65–75 years) had the highest prevalence of raised systolic and diastolic blood pressures. The figures in men were 39·6% of systolic blood pressure and 17·6% of diastolic blood pressure, and in women were 35·5% of systolic blood pressure and 12·0% of diastolic blood pressure.

In the current research, the prevalence of raised systolic and diastolic blood pressures in men were 13·1% and 12·4%, respectively; whereas the prevalence of raised systolic and diastolic blood pressures in women were 6·4% and 4·8%, respectively. These figures are lower than those in the Health Survey for England 2006 (2008), in which the prevalence of hypertension was 34% in men, and 32% in women. These figures are also lower comparable to the USA. In the US NHANES 1999–2002, hypertension prevalence was much lower, 29·0% in women versus 27·8% in men (CDC 2005). As mentioned earlier for the obesity issue, wealth might be a factor to explain the difference. This could be applied to hypertension. In terms of treatment, a diet rich in fruits, vegetables, and low-fat dairy foods with reduced saturated and total fat can substantially lower blood pressure, concluded the findings in the DASH trial (Appel *et al.* 1997). However, it is important to emphasise that DASH trial was an 11-week feeding study. It was not designed to identify the effective or ineffective components of the diets. Adherence to the diets among people selecting their own food or the long-term effects of the diets on blood pressure and clinical cardiovascular events. But several clinical and public health benefits—eg, an effective nutritional approach to preventing hypertension, effective alternative to drug therapy, and potentially shift the population distribution of blood pressure downward, reducing the occurrence of blood pressure-related cardiovascular disease—are also implied. Such a diet offers an additional nutritional approach to the prevention and treatment of hypertension.

The difference between my study and other studies could be explained by the different techniques or under certain conditions used for measurement. Any definition of hypertension should be based on the assumption that appropriate techniques are used for the measurement and that the conditions under which the measurement is obtained are described. Guidelines for defining hypertension have been modified by expert panels over time to lower blood pressure levels as more information has become available. JNC VII, published in 2003, defines normal blood pressure as <120/80 mm Hg (Chobanian *et al.* 2003). This definition is based primarily

on epidemiologic data rather than on outcomes of clinical trials. Individuals with systolic blood pressure 120–139 mm Hg or diastolic blood pressure 80–89 mm Hg are considered prehypertensive, and individuals with systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg are considered to have hypertension. These guidelines are based on the average of two or more seated blood pressure readings during each of two or more office visits. Home blood pressures and average 24 h ambulatory blood pressures are generally lower than clinic blood pressures. A blood pressure of 135/85 mm Hg has been recommended as the upper limit of normal for home and average awake ambulatory blood pressures (Pickering *et al.* 2005). White-coat hypertension, also associated with increased cardiovascular disease risk, has been defined as a blood pressure persistently $\geq 140/90$ mm Hg in the office or clinic and an average awake ambulatory reading $< 135/85$ mm Hg (Verdecchia *et al.* 2003).

The prevalence of hypertension was increasing with the increase of age in women, but in men before age 65 years old. This finding is in line with many studies which documented an increase in hypertension prevalence with age (Burt *et al.* 1995; CDC 2005; Hajjar and Kotchen 2003; Vasan *et al.* 2002; Whelton *et al.* 2004; Wolf *et al.* 1997; Wolf *et al.* 2003). In the current study, the prevalence of raised systolic blood pressure in women was higher than in men aged 65–75 years (35.5% vs 33.9%). This is similar to other research which documented individuals aged 60 or older, in which mean systolic blood pressure for women was higher than that for men (Hajjar *et al.* 2001). This is because most clinical trials, to ensure adequate events, limit recruitment to patients older than 55 years and have usually reported a mean age of the study populations of more than 65 years. Thus, younger patients are poorly represented in outcome trials. This is a concern because modern prevention strategies for cardiovascular diseases increasingly advocate the importance of primary prevention and treatment of increasing numbers of younger patients. It is conceivable that in younger patients, subtle differences in drug effects on various surrogate or “intermediate” disease markers could have an important beneficial effect over the long term (Williams 2005). However, many developing countries do not experience increases in prevalence of high blood pressure and hypertension with age (Kaminer and Lutz 1960; Oliver *et al.* 1975; Pavan *et al.* 1997; Sever *et al.* 1980; Stamler *et al.* 1976; Truswell *et al.* 1972). A common characteristic of these populations is a low dietary salt intake (Elliott *et al.* 1996). When these populations migrate to a more developed society, hypertension prevalence does increase with age (He *et al.* 1991).

4.4.4 Plasma cholesterol

Men in group 4 had the highest prevalence of high total cholesterol and LDL, as well as low HDL; whereas women in group 5 had the highest prevalence of high total cholesterol, group 6 had the highest prevalence of high LDL, and group 1 (ages 18-24 years) had the highest prevalence of low HDL.

In the Health Survey for England 2006, the prevalence of high total cholesterol was 57% in men and 61% in women. In men, the prevalence of high total cholesterol increased in those aged less than 55 years, but decrease aged 55 years and older. It is a slightly different in women, in which the prevalence was going up with the increase of age at less than 65 years, and decreased aged 65 years and older. Women are more likely to have higher total cholesterol than men aged 16–24 years, but less likely aged 25–44 years. The absolute difference between men and women aged 45–54 years is 4%, which is the smallest gap in all age groups, but women are more likely to have higher total cholesterol than men aged 45 years and older.

Our findings were in agreement with Health Survey for England 2006. In that survey, men were about five times more likely to have lower HDL than women. The prevalence of low HDL was 1·8% in women, and 9·4% in men. In the current research, although the rates were higher, the prevalence of low HDL was 3·0% in women, and 15·0% in men. The prevalence of low HDL in men was going down with the decrease of the age less than 55 years, and was much the same between age groups of 45–54 years and 55–64 years, then increase aged 65–74 years. It then decreased again aged 75 years and older. In women, the prevalence of low HDL was much the same in age groups 16–24 years, 25–34 years and 65–74 years, which was 2·2%. The prevalence was going down with the increase of the age less than 65 years, and the lowest prevalence of low HDL was found in women aged 75 years and older, which was 0·2%.

4.4.5 Strengths and limitations

There are some similarities between European Health Interview Survey and my study. European Health Interview Survey used Health Survey for England 2009 as the data source for United Kingdom. In the survey, adults were asked questions about the general health, alcohol

consumption, smoking, fruit and vegetable consumptions. The core sample of Health Survey for England 2009 comprised 4680 addresses selected at random in 360 postcode sectors. Although this was a short period of survey with a small sample size, which showed the strength of the present study having a larger sample size, the population in Health Survey for England 2009 should be representable because my study population is more affluent. Most of the participants were employees and could afford private medical insurance. Blood pressure in the Health Survey for England 2009 used Omron HEM 907, but the investigators consider systolic and diastolic blood pressure of 180/115 mm Hg as raised, which is different from the cut-off point in my study (140/90 mm Hg), so there is a possibility for the prevalence of hypertension is much higher in my study. Blood sample was non-fasting, and was analysed by Olympus 640 analyser; this analyser is operated by a professional staff, so the errors should be reduced to minimum and higher precision than finger prick. The data difference between Health Survey for England 2009 and my study could also be due to the period of data collection. There is also a difference in the design of the study, which HSE 2009 was a cross-sectional survey, and my study is a retrospective study.

Differences between ethnic groups in various modifiable cardiovascular risk factors were not analysed in this study because ethnic group was not recorded by the company. However, several population-based studies in the UK have investigated ethnic differences in order to explain the variability in cardiovascular disease mortality and morbidity. Some authors reported a raised prevalence of hypertension in Afro-Caribbean populations and in south Asians. Additionally, most of these studies have also reported significantly higher mean blood pressure levels in both Afro-Caribbean populations and south Asian men compared with white Caucasian populations (Cappuccio *et al.* 1997; Chaturvedi *et al.* 1993; Primatesta *et al.* 2000).

The medication of the participants in the dataset was also not recorded. However, Roth and colleagues (2010) conducted an analysis of medication coverage and therapeutic control in total cholesterol from eight countries including England. Their findings suggested that effective delivery of cholesterol lowering medication has increased three times in England and five times in the USA during the past two decades. This was associated with the increase use of medication among the diagnosed population rather than an increase in the fraction of the population that is diagnosed. Therefore, efforts to screen more people and make them aware of their high total cholesterol concentrations have been less successful than efforts to deliver

treatment to those who know they are hypercholesterolaemic. The assessment of diagnosis and medication use was based on a self-reported response. There were therefore concerns about the data validity, reliability and comparability. Also, the available data often came from different time periods, so, comparisons across countries may be confounded. In this study, investigators defined high total cholesterol as ≥ 6.2 mmol/l, which is now considered to be higher than optimal.

Our data showed that participants registered in the private medical company were more likely to be overweight, especially men who were almost twice as likely as were women. One in two men were overweight when using BMI as a measurement. Compared with participants in Health Survey for England 2006, our findings showed that participants had much a lower prevalence of hypertension and raised total cholesterol. Men and women had a similar pattern on the prevalence of low HDL, which in men was five times higher than in women. There is little research evidence about the prevalence of LDL and WHR, with the most available evidence on LDL having a focus on therapeutic coverage. Because participants are registered in a private medical insurance company, it is likely that socioeconomic status in this research is significantly different from those in the Health Survey for England 2006. Socioeconomic status has a strong effect on cardiovascular disease and associated risk factors, therefore, research is needed to evaluate socioeconomic status on cardiovascular risk factors in those people who attend private medical screening. Finally, our findings showed some similarity with existing studies, especially in the UK population. Most importantly, our dataset is one of the largest UK from a commercial setting. More research in the private sector is needed because the current UK NHS reform will involve greater participation of NHS hospitals with private patients.

4.5 CONCLUSION

The findings are mixed when compared this affluent population to the general population in the Health Survey for England. Using BMI as a measurement, men attended the Nuffield Health seemed more likely to be overweight but less likely to be obese than were those in Health Survey for England; women were less likely to be overweight and obese. However, when using waist circumference as a measurement for overweight and obese, compared with

the population in the Health Survey for England 2006, men and women were shown to be less obese in the current research findings. Men and women attended the Nuffield Health seemed less likely to have higher total cholesterol than were those in Health Survey for England. Men were about five times more likely to have lower HDL than women, but the prevalence was lower in Health Survey for England than were those in the Nuffield Health both in men and women. As can be seen, these differences about prevalence of cardiovascular risk factors in the two populations, it is therefore important to compare the populations from similar socioeconomic groups or regions because they might have much the same cardiovascular outcomes.

In Chapter 7, a public-funded NHS dataset was provided by the Hampshire Health Record. South England region, where the Hampshire Health Record collected its data, is a more affluent region in the UK compared with other regions in terms of the Indices of Multiple Deprivation (IMD) 2007 score. Nuffield Health is a private medical insurance company, so people who attended Nuffield Health were more likely to be from a higher socioeconomic class. Therefore, Chapter 7 aims to compare the prevalence of various modifiable cardiovascular risk factors between Nuffield Health (private health screening) and Hampshire Health Record (NHS Trust), and to identify the similarities and differences of the two datasets in relation to the cardiovascular risk factors.

People aged 55–75 signed up the private medical insurance are more likely to have more than one cardiovascular risk factor. Although they are generally healthy and wealthy, there is a possibility to develop cardiovascular disease due to the high prevalence of cardiovascular risk factors in this age group. Compared to the other age groups, this special age group deserves more attention. They might need more attention to their lifestyle and diet, and exercise more.

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CHAPTER 5:

SOCIOECONOMIC STATUS AND MODIFIABLE CARDIOVASCULAR RISK FACTORS IN PEOPLE ATTENDING PRIVATE MEDICAL SCREENING: AN OBSERVATIONAL STUDY

ABSTRACT

Aim: Many modifiable cardiovascular risk factors are strongly related to socioeconomic position. This chapter aims to examine the influence of socioeconomic status and other covariates on modifiable cardiovascular risk factors in people attended private health screening.

Methods: A retrospective study of 60,334 participants aged between 18 and 75 across the UK was conducted using a dataset provided by a private healthcare company. Eight risk factors were analysed: body mass index (BMI), waist size, waist-to-hip ratio (WHR), systolic and diastolic blood pressure, total cholesterol (TC), HDL-C and LDL-C. The English Indices of Deprivation 2007 scale was used to allocate deprivation scores, and the cohort was divided by quintile (group 1 being the least deprived and group 5 the most deprived).

Results: After adjusting for age, sex and smoking, obesity (BMI) were significantly higher in the two most deprived quintiles (Group 4: odds ratio=1.14, 95% CI 1.05, 1.25, $p=0.002$ and Group 5: odds ratio=1.24, 95% CI 1.13, 1.36, $p<0.001$). Waist circumference was significantly higher in the three most deprived quintiles (Group 3: odds ratio=1.15, 95% CI 1.06, 1.24, $p=0.001$; Group 4: odds ratio=1.17, 95% CI 1.07, 1.27, $p<0.001$ and Group 5: odds ratio=1.23, 95% CI 1.13, 1.34, $p<0.001$) and, compared with the least deprived group, all other groups had a greater likelihood of age-, sex- and smoking- adjusted waist-to-hip ratio. Adjusted odds ratio for systolic blood pressure was the highest in participants from group 4 (odds ratio=1.07, 95% CI 0.97, 1.18), and lowest in groups 2 (odds ratio=0.95, 95% CI 0.86, 1.05) and 5 (odds ratio=0.95, 95% CI 0.85, 1.06), but no statistically significance was shown among five groups. Adjusted odds ratio for diastolic blood pressure was significant lower in participants from the least deprived group (odds ratio=0.83, 95% CI 0.74, 0.94, $p=0.002$). Compared with the least deprived group, the three most deprived groups were significantly less likely to have raised

total cholesterol, and statistical significance was shown in the most deprived group (odds ratio=0.84, 95% CI 0.78, 0.91, $p<0.001$) Compared with the least deprived group, the likelihood of elevated low density lipoprotein was decreased in the two most deprived groups, and statistical significance was shown in the most deprived group (odds ratio=0.84, 95% CI 0.77, 0.91, $p<0.001$). There was a general trend towards a lower likelihood in more deprived groups, but overall there were no significant between-group differences in the likelihood of having a low HDL subfraction between these groups.

Discussion: The present data concur with previous findings, showing a positive association between anthropometric indices of adiposity and deprivation. This was evident for BMI in the most deprived groups, but much more so, for waist circumference and WHR where all groups were more likely to be centrally obese compared with the least deprived. The prevalence of all anthropometric measures indicating obesity was high in women. It appears from the present data, that being within the most deprived group was a significant predictor of having a more healthy blood pressure reading. Like blood pressure, plasma cholesterol is a risk factor often associated with increased adiposity. In this study, participants from the least deprived areas had less favourable serum lipids compared with those individuals from the most deprived areas. However, both total cholesterol and low-density lipoprotein cholesterol measures were significantly lower in the most deprived groups. Indeed it appears from the present data, being in the most deprived group (only) was a significant predictor of having a more healthy plasma lipid reading.

Conclusion: Our study indicated that the mechanisms underlying the association between socioeconomic status and modifiable cardiovascular risk factors are complex. In conclusion, in this retrospective study of 55,217 participants attending private medical screening, we have shown that people are more likely to be obese, but less likely to have hypertension, raised total cholesterol and LDL in the most deprived areas compared with the least deprived areas. Hence, individuals in the most deprived areas remain to be a target population for prevention of obesity.

5.1 INTRODUCTION

Cardiovascular disease accounts for around 30% of global deaths each year, and it is still growing, from 17.1 million in 2004 to an anticipated 23.4 million in 2030 (Chockalingam *et al.* 2000; Mathers *et al.* 2006; WHO 2008). The landmark INTERHEART case-control study across 52 countries identified nine modifiable cardiovascular risk factors which accounted for over 90% of the contribution to risk of an initial acute myocardial infarction for young men and women worldwide. These are: cholesterol, smoking, blood pressure, diabetes, abdominal obesity (waist-to-hip ratio), psychosocial factors (including depression and stress), consumption of fruits and vegetables, consumption of alcohol, and physical activity (Yusuf *et al.* 2004).

A recent report published by the Institute of Medicine (2010) noted that cardiovascular disease is not only a foremost cause of death in high income countries, but has also become a major impact in low and middle income countries. The increased prevalence of risk factors for cardiovascular disease including tobacco use, poor nutrition, low physical activity, elevated blood lipids, and hypertension. These reflect significant global changes in behaviour and lifestyle in both high and low middle income countries (Daar *et al.* 2007; IOM 2010; Marmot and Wikinson 1999). These risk factors were associated with social determinants such as income, wealth, and educational attainment.

Socioeconomic status is a measurement of individual characteristics such as occupation, income and educational level, or characteristics of the area in which individuals live. In terms of educational levels, Roohafza *et al.* (2005) found an inverse association with several cardiovascular risk factors such as serum cholesterol, blood pressure and BMI, but no significant association with smoking. Occupation is a social determinant which is independently associated with cardiovascular risk factors (Gregory *et al.* 2007; McFadden *et al.* 2008). If the behaviours impacting on energy imbalance do not change, this imbalance may accumulate over time, resulting in an accelerated rate of weight gain among low socioeconomic groups (Ball and Crawford 2004). There is a strong relationship between occupational social class, high blood pressure and cholesterol level. Manual workers are at higher risk of cardiovascular disease than non-manual workers (Rose *et al.* 1981; Woodward *et al.* 1992). The association between income and cardiovascular risk factors are found in the US National

Health and Nutrition Examination Survey (NHANES)—prevalence of hypertension decreased from the lowest to highest income groups. This was also found in Finnish men from three regions (Harald *et al.* 2008; Kanjilal *et al.* 2006). However, a different pattern was found in a Canadian cross-sectional study examining the trends of modifiable cardiovascular risk factors from the perspective of socio-demographic correlates. Regional variations and temporary trends that hypertension was detected in all income groups. (Lee *et al.* 2009).

Using professional classification, Emberson *et al.* (2004) found that BMI was higher in manual than non-manual UK workers. Puslaw (2008) found that higher BMI values were found with a decrease in professional classification. Dragano *et al.* (2005) found that people having the least education were twice as likely to be obese than the most educated in Czech Republic. This ratio was 1.6 in Germany. Stafford and colleagues (2010) found that residence in a more deprived neighbourhood contributed to a higher initial BMI when the study started. There was also a note that in the longitudinal, multilevel Whitehall II study over 13 years follow-up using Townsend index of multiple deprivation at census-ward level, participants from the most-deprived neighbourhoods experienced relatively greater weight gain over time, an increase of 1.5kg/m² in men and 1.4kg/m² in women. Wang *et al.* (2007) gathered five cross-sectional surveys conducted by the Stanford Heart Disease Prevention Programme between 1979 and 1990 and found that participants from low socioeconomic neighbourhoods had a higher mean BMI than those from high socioeconomic neighbourhoods, after adjusting for age, gender, ethnicity, individual-level socioeconomic status, smoking, physical activity and nutrition knowledge. A similar finding has also been established in the GLOBE study (van Lenthe and Mackenbach 2002); the odds ratios of BMI increased significantly with increasing neighbourhood deprivation, after adjusting for sex.

Chen and Tunstall-Pedoe (2005) conducted the Scottish MONICA survey in 2,233 men and 2,516 women aged 25-64 years to investigate the relationship of waist circumference to socioeconomic deprivation, measured by the Carstairs Index. In this cross-sectional survey, they also compared the relationship of waist circumference to WHR and BMI and found that a large waist circumference has a closer relationship than WHR and BMI to the socioeconomic deprivation in men and women, although waist circumference, WHR and BMI increased with level of deprivation significantly in both sexes. The situation between the highest and lowest income groups in terms of the prevalence of hypertension in developed countries such as USA

and European countries are different from the developing countries. In the developed countries, the Kuopio Ischemic Heart Disease Risk Factor Study found that, after adjustment for smoking, hypertension, dyslipidemia, and diabetes, it resulted in a modest (24%) attenuation of the relative socioeconomic gradient of CHD risk. The most deprived groups still had higher risks compared with those in the least deprived groups. These risk factors accounted for most (72%) of the absolute socioeconomic gradient (Lynch *et al.* 2006). In developing countries, a study of low-income rural women in Mexico similarly observed an inverse association between educational attainment and systolic blood pressure and a positive association with income, housing and asset index (Fernald *et al.* 2008). A cross-sectional study assessed hypertension in an urban working population in Ghana. It showed a lower prevalence of hypertension in participants of the most deprived groups and highest prevalence in those of the least deprived groups with an inconsistent pattern among participants in the intermediate deprived groups. There was a suggested negative association between the level of education and hypertension after controlling for the other measures of social indicators, such as employment and current wealth (Addo *et al.* 2009).

Socioeconomic status is one of the strongest predictors of morbidity and premature mortality (Winkleby *et al.* 1992). Many cardiovascular risk factors are strongly related to socioeconomic status (Emberson *et al.* 2004; Huisman *et al.* 2005; Kanjilal *et al.* 2006; Kivimaki *et al.* 2007), Ellaway *et al.* (1997) found an increasing mean BMI with an increasing level of deprivation. Reijneveld (1998) noted a statistically significantly increased risk of obesity ($\text{BMI} > 27 \text{ kg} \cdot \text{m}^2$) in the most, compared with the least deprived areas. This remained significant after adjustment for three indicators of social status. Cardiovascular risk is determined by the area of residence, independently and in addition to the effect of individually measured socioeconomic status (Ashworth *et al.* 2008; Sundquist *et al.* 2004). Kerr *et al.* (2008) showed that a high burden of modifiable cardiovascular risk factors, particularly in younger people among Maori and Pacific people from areas of high deprivation in New Zealand.

At present, several area-based indices have sought to measure socioeconomic status as distinct from individual socioeconomic position (Payne *et al.* 2009; Stewart *et al.* 2009; Townsend 1987). Deprivation indices are easier to apply in clinical practice than most other measurement of socioeconomic status (Blakely *et al.* 2002), and have consequently become popular among public health researchers. This is because information about individual measures of

socioeconomic status may be incomplete and potentially inaccurate. When employed as a dependent measure, deprivation indices provide a way by which routine population-based primary care data can be used to examine the effects of socioeconomic deprivation in determining cardiovascular risk factors.

Cardiovascular risk factors and the prevalence of cardiovascular disease itself are both associated with deprivation or analogous measures such as socioeconomic status, but few data from private medical companies are available in the UK. The aim of this chapter is, therefore, to examine the association between area-level status and objectively-measured, modifiable cardiovascular risk factors in a non-clinical UK population who attended private health screening.

5.2 MATERIAL AND METHODS

5.2.1 Study setting and data collection

Data were provided by a private health-care company, Nuffield Health. Identification of individuals is not possible from these data, because they are provided by a unique patient reference number in a dataset. The assessment programmes were delivered through a bespoke electronic patient-record system developed exclusively for Nuffield Health, the Vi System. This system offers greater accuracy and speedier and more comprehensive reports than other systems (eg, paper-based systems). It has four interventions—Vi₃, Vi₄, Vi₅, and Vi₆. It provides instant comparison with previous test results and the ability for clients to use any of their centres in the UK and immediately access the records. Data were extracted from the records of the Nuffield Health. Aggregate data provided by the Nuffield Health were anonymised, in line with the Information Commissioner Office's (2013) anonymisation code, it can be freely processed and publicly disclosed. Data were recorded for participants during screening for provision of employment-related medical care. At each of the company's testing sites, data were collected by trained health professionals using protocols consistent with the British Hypertension Society (for blood pressure and blood analysis) and American College of Sports Medicine (for anthropometry).

5.2.2 Individual level cardiovascular risk factors

Several established cardiovascular risk factors represent the risk profile of the participants: (1) anthropometric characteristics; (2) blood pressure; and (3) plasma serum. We examined BMI, WHR, and waist circumference. Obesity was examined by BMI, waist-to-hip ratio (WHR), waist circumference, separately. BMI was classified as obese if over 30 kg/m². Waist circumference was measured at the anatomical waist, central obesity was defined as greater than 102cm in men and greater than 88 cm in women. The waist-to-hip ratio was calculated and defined as high if values were greater than 0.95 in men and greater than 0.80 in women (Croft *et al.* 1995). Hypertension was classified as greater than 90 mm Hg (diastolic) and greater than 140 mm Hg (systolic; NICE 2006b). Plasma serum includes total, HDL, and LDL cholesterol. Arterial blood was drawn and analysed. Total cholesterol, LDL subfraction, and HDL subfraction were measured. Total cholesterol was classified as raised if higher than 6.0 mmol/L. HDL was classified as low if less than 1.0 mmol/L; LDL was defined as raised if greater than 3.36 mmol/L (Contois *et al.* 1996).

5.2.3 Individual level covariates

Age and sex were adjusted in all multivariate analyses. Age was defined as a continuous variable. On the basis of current evidence (Purslow *et al.* 2008; Stafford *et al.* 2010) and available data collection, smoking was defined as covariates and it has been divided into three categories – none (never smoked and given up), light smoker (no more than 10 per day) and heavy smoker (above 10 per day).

5.2.4 Area level socioeconomic status

The English Indices of Deprivation (Noble *et al.* 2008) were calculated from each clients' home postcode. This was used to compare the different risk factors from the least deprived to the most deprived areas. These area level indices can be used to contrast disadvantaged areas or populations (Carstairs *et al.* 1995; DETR Indices of Deprivation 2000; Morris *et al.* 1991). The Indices were established to capture the multidimensional concept of socioeconomic deprivation and are based on various indicators within seven distinct domains—income, employment,

health and disability, living environment, crime, barriers to housing and services, and education, skills and training. A total of 38 indicators are distributed across these seven domains, with the aim of measuring both financial resources and consequent outcomes. The English Indices of Deprivation 2007 scale was used to allocate deprivation scores on the basis of postcode, and the cohort was divided by quintile (group one being the least deprived and group five being the most deprived). This was used to compare the different risk factors from the least deprived to the most deprived areas.

5.2.5 Statistical Analysis

Descriptive statistics were generated. Binary logistic regressions were performed to investigate the impact of socioeconomic status on different modifiable cardiovascular risk factors, as measured in people attending private healthcare screening. The association between groups and cardiovascular risk factors was evaluated by the odds ratios after adjustment for age, sex, smoking and deprivation. Both results are compared in the statistical analysis. Data from this study were analysed by using SPSS Version 17.0 (SPSS, Inc., Chicago, IL). All baseline data were analysed at a 0.05 alpha level to determine statistical significance.

5.3 RESULTS

5.3.1 Descriptive statistics for Nuffield dataset in different measures

A retrospective study of 55 217 participants aged between 18-75 years old across the UK was selected for analysis. Demographic and clinical characteristics of the population in different socioeconomic groups in the format of mean and standard deviation (SD) values are shown in Table 5.1. As we could see from the comparison below, the study population attended the Nuffield Health are slightly affluent in the two least groups, and about twice as affluent than national IMD rank in the two most deprived groups

Table 5.1: Demographic and clinical characteristics of the population in different socioeconomic groups (mean and SD) in private dataset

	Group 1	Group 2	Group 3	Group 4	Group 5
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	(least deprived) n=11185	n=10905	n=11051	n=11033	(most deprived) n=11043
Demographic characteristics					
Age (years)	46.6 (10)	46.2 (10)	45.7 (11)	43.6 (11)	40.0 (11)
Male	7334 (65.6%)	6983 (64.0%)	6784 (61.4%)	6419 (58.2%)	6095 (55.2%)
Study population IMD rank (Median &SD)	31,147 (1043)	27,587 (1167)	22,945 (1532)	17,215 (2046)	8,625 (4392)
National IMD rank	29,234	22,737	16,241	9,745	3,248
BMI (kg/m ²)	26.31 (4.04)	26.28 (4.10)	26.26 (4.13)	26.13 (4.31)	25.83 (4.44)
Waist	89.6 (12.53)	89.7 (12.58)	89.5 (12.86)	88.7 (13.11)	87.2 (13.13)
WHR	0.87 (0.08)	0.87 (0.08)	0.87 (0.08)	0.86 (0.09)	0.85 (0.09)
Clinical characteristics					
SBP	125 (15.13)	124 (14.90)	124 (15.26)	123 (15.18)	121 (14.53)
DBP	80 (9.75)	80 (9.67)	80 (9.83)	79 (9.91)	77 (9.72)
Cholesterol (mmol/l)					
Total	5.4 (0.98)	5.3 (0.99)	5.3 (1.01)	5.3 (1.00)	5.1 (1.00)
HDL	1.5 (0.42)	1.5 (0.41)	1.5 (0.42)	1.5 (0.42)	1.5 (0.40)
LDL	3.2 (0.89)	3.2 (0.90)	3.2 (0.92)	3.1 (0.89)	3.0 (0.86)

5.3.2 Anthropometric characteristics

Mean BMI was the highest in participants from the least deprived areas and the lowest in those from the most deprived areas. Socioeconomic status has a very limited influence on BMI, as there was no statistical significance was shown between groups. Multiple logistic regression models were constructed to assess the effects of socioeconomic status on the impact of BMI. Table 5.2 shows the odds ratio after adjusting for age, sex, smoking and socioeconomic status.

Table 5.2: Anthropometric characteristics (BMI, waist circumference and WHR) after adjusted for age-, sex-, smoking- and deprivation groups (odds ratio and 95%CI) in private dataset

Risk factors	Number of people	Model	
		Odds ratio (95%CI)	p value
Body mass index (Obese)	55032		
Deprivation groups			
Group 1 (least deprived)	11148	1.00	
Group 2	10900	1.00 (0.92-1.09)	0.91
Group 3	10988	1.03 (0.94-1.12)	0.52
Group 4	11018	1.14 (1.05-1.25)	0.002
Group 5 (most deprived)	10978	1.24 (1.13-1.36)	0.000
Sex			
Male		1.00	
Female		0.69 (0.65-0.77)	0.000
Age		1.02 (1.016–1.022)	0.000
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		0.89 (0.78-1.02)	0.09
2 (heavy smoker)		1.19 (1.03-1.38)	0.017
Waist circumference (Obese)	51042		
Deprivation groups			
Group 1 (least deprived)	10529	1.00	
Group 2	10237	1.07 (0.99-1.16)	0.09
Group 3	10269	1.15 (1.06-1.24)	0.001
Group 4	10105	1.17 (1.07-1.27)	0.000
Group 5 (most deprived)	9902	1.23 (1.13-1.34)	0.000
Sex			
Male		1.00	
Female		1.31 (1.24-1.38)	0.000
Age		1.035 (1.033–1.038)	0.000
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		1.05 (0.93-1.19)	0.40
2 (heavy smoker)		1.40 (1.23-1.60)	0.000
Waist-hip-ratio (WHR) (Obese)	51049		
Deprivation groups			
Group 1 (least deprived)	10530	1.00	
Group 2	10238	1.15 (1.07-1.23)	0.000
Group 3	10270	1.16 (1.08-1.25)	0.000
Group 4	10107	1.23 (1.14-1.33)	0.000
Group 5 (most deprived)	9904	1.29 (1.19-1.39)	0.000
Sex			
Male		1.00	
Female		2.96 (2.82-3.11)	0.000
Age		1.055 (1.052–1.057)	0.000
Smoking			

0 (non-smoker)		1.00	
1 (light smoker)		1.30 (0.17-1.45)	0.000
2 (heavy smoker)		1.87 (1.65-2.12)	0.000

In multivariate models, females were less likely to be obese (odds ratio=0.69, 95% CI 0.65, 0.77, $p<0.001$), but more likely to be centrally obese (odds ratio=1.31, 95% CI 1.24, 1.38, $p<0.001$) and to have an elevated waist-to-hip ratio (odds ratio=2.96, 95% CI 2.82, 3.11, $p<0.001$). Age-, sex- and smoking- corrected odds for obesity (BMI) were significantly higher in the two most deprived quintiles (Group 4: odds ratio=1.14, 95% CI 1.05, 1.25, $p=0.002$ and Group 5: odds ratio=1.24, 95% CI 1.13, 1.36, $p<0.001$). Waist circumference was significantly higher in the three most deprived quintiles (Group 3: odds ratio=1.15, 95% CI 1.06, 1.24, $p=0.001$; Group 4: odds ratio=1.17, 95% CI 1.07, 1.27, $p<0.001$ and Group 5: odds ratio=1.23, 95% CI 1.13, 1.34, $p<0.001$) and, compared with the least deprived group, all other groups had a greater likelihood of age, sex and smoking adjusted waist-to-hip ratio.

5.3.3 Blood pressure measurements

Mean value of systolic and diastolic blood pressure is higher in the participants from the least deprived areas than those from the most deprived areas (Table 5.1). Table 5.3 shows the odds for hypertension after adjusting for age, sex, smoking and deprivation. Adjusted odds ratio for systolic blood pressure was the highest in participants from group 4 (odds ratio=1.07, 95% CI 0.97, 1.18), and lowest in groups 2 (odds ratio=0.95, 95% CI 0.86, 1.05) and 5 (odds ratio=0.95, 95% CI 0.85, 1.06), but no statistically significance was shown among five groups. Adjusted odds ratio for diastolic blood pressure was significant lower in participants from the least deprived group (odds ratio=0.83, 95% CI 0.74, 0.94, $p=0.002$)

Table 5.3: Blood pressure (systolic and diastolic) after adjusted for age-, sex- smoking-, and deprivation groups (odds ratio and 95%CI) in private dataset

Risk factors	Number of people	Model	
		Odds ratio (95%CI)	p value
Systolic blood pressure	55005		
Deprivation groups			
Group 1 (least deprived)	11142	1.00	
Group 2	10890	0.95 (0.86-1.05)	0.30
Group 3	10983	0.97 (0.88-1.07)	0.59
Group 4	11008	1.07 (0.97-1.18)	0.19
Group 5 (most deprived)	10982	0.95 (0.85-1.06)	0.35
Sex			
Male		1.00	
Female		0.57 (0.53-0.61)	0.000
Age		1.071 (1.068–1.075)	0.000
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		0.89 (0.75-1.07)	0.215
2 (heavy smoker)		1.31 (1.10-1.56)	0.002
Diastolic blood pressure	55019		
Deprivation groups			
Group 1 (least deprived)	11148	1.00	
Group 2	10894	0.90 (0.81-0.99)	0.30
Group 3	10984	0.98 (0.89-1.08)	0.66
Group 4	11011	0.96 (0.86-1.06)	0.41
Group 5 (most deprived)	10982	0.83 (0.74-0.94)	0.002
Sex			
Male		1.00	
Female		0.44 (0.40-0.47)	0.000
Age		1.036 (1.033–1.039)	0.000
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		0.91 (0.76-1.09)	0.315
2 (heavy smoker)		1.37 (1.15-1.63)	0.000

In multivariate models, females were less likely than male to have elevated systolic and diastolic blood pressure (odds ratio=0.57, 95% CI 0.53, 0.61, $p<0.001$ vs odds ratio=0.44, 95% CI 0.40, 0.47, $p<0.001$).

5.3.4 Plasma cholesterol measurements

Mean value of total cholesterol is higher in the participants from the least deprived areas than those from the most deprived areas (Table 5.1). Very similar mean values of HDL and slightly difference on mean values of LDL between groups (Table 5.1). Table 5.4 shows the odds ratio for raised total and LDL cholesterol or low HDL cholesterol after adjusting for age, sex, smoking and deprivation. Compared with the least deprived group, the three most deprived groups were significantly less likely to have raised total cholesterol, and statistical significance was shown in the most deprived group (odds ratio=0.84, 95% CI 0.78, 0.91, $p<0.001$). Compared with the least deprived group, the likelihood of elevated low density lipoprotein was decreased in the two most deprived groups, and statistical significance was shown in the most deprived group (odds ratio=0.84, 95% CI 0.77, 0.91, $p<0.001$). There was a general trend towards a lower likelihood in more deprived groups, but overall there were no significant between-group differences in the likelihood of having a low HDL subfraction between deprivation groups.

Table 5.4: Plasma cholesterol (total cholesterol, HDL and LDL) after adjusted for age-, sex-, smoking- and deprivation groups (odds ratio and 95%CI) in private dataset

Risk factors	Number of people	Model	
		Odds ratio (95%CI)	p value
Total Cholesterol	45108		
Deprivation groups			
Group 1 (least deprived)	9550	1.00	
Group 2	9437	0.96 (0.90-1.03)	0.27
Group 3	9339	0.94 (0.88-1.01)	0.09
Group 4	8870	0.94 (0.88-1.01)	0.11
Group 5 (most deprived)	8002	0.84 (0.78-0.91)	0.000
Sex			
Male		1.00	
Female		0.71 (0.68-0.75)	0.000
Age		1.042 (1.040–1.045)	0.000
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		1.16 (1.04-1.30)	0.01
2 (heavy smoker)		1.26 (1.10-1.44)	0.001
HDL	45108		
Deprivation groups			
Group 1 (least deprived)	9549	1.00	
Group 2	9349	0.97 (0.87-1.08)	0.61
Group 3	9340	1.06 (0.95-1.17)	0.32
Group 4	8868	1.00 (0.89-1.12)	0.96
Group 5 (most deprived)	8002	0.98 (0.87-1.11)	0.81
Sex			
Male		1.00	
Female		0.16 (0.14-0.18)	0.000
Age		0.994 (0.990–0.997)	0.001
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		1.38 (1.17-1.63)	0.000
2 (heavy smoker)		2.10 (1.78-2.48)	0.000
LDL	44421		
Deprivation groups			
Group 1 (least deprived)	9407	1.00	
Group 2	9222	1.05 (0.98-1.13)	0.13
Group 3	9214	1.02 (0.96-1.10)	0.49
Group 4	8707	0.95 (0.88-1.02)	0.14
Group 5 (most deprived)	7871	0.84 (0.77-0.91)	0.000
Sex			
Male		1.00	
Female		0.51 (0.48-0.53)	0.000
Age		1.034 (1.032–1.036)	0.000
Smoking			
0 (non-smoker)		1.00	
1 (light smoker)		1.15 (1.02-1.29)	0.02
2 (heavy smoker)		1.24 (1.08-1.41)	0.002

In multivariate models, females were less likely than males to have raised total cholesterol and LDL (odds ratio=0.71, 95% CI 0.68, 0.75, $p<0.001$ vs odds ratio=0.51, 95% CI 0.48, 0.53, $p<0.001$), and less likely to have low HDL (odds ratio=0.16, 95% CI 0.14, 0.18, $p<0.001$)

5.4 DISCUSSION

5.4.1 Overall findings of this study

The aim of this study was to determine the association between socioeconomic deprivation and three groups of objectively measured, modifiable cardiovascular risk factors; adiposity, blood pressure, and plasma cholesterol. Measures, such as BMI, can be collected with relative ease in large, population-based samples such as NHANES and the HSE. Cholesterol measures from blood are more difficult to obtain and, until recently, routine screening has not been in place. Clinical samples, from GP surgeries have an inherent bias, as individuals giving these samples typically have health problems, necessitating the GP visit.

The published literature, in which risk factors were usually clustered, the outcome showed contrasting or paradoxical findings compared with this research—greater adiposity was found in people from more deprived groups estimated by all three measures: BMI, waist circumference and WHR. The findings also showed that the likelihood of having high blood pressure, however, was lower in the most deprived area than in the least deprived area. The likelihood of having low HDL was similar between groups, but the likelihood of having high total cholesterol and LDL was statistically significant lower in more deprived groups.

5.4.2 Adiposity

BMI is a widely used method for the definition of obesity. However, Sönmez *et al.* (2003) found that the rate of obesity diagnosed by BMI was lower than those diagnosed by waist circumference and WHR. Some authors considered that waist circumference could be a more accurate method for the definition of obesity and prediction of cardiovascular diseases (Han *et al.* 1995; Ho *et al.* 2001; Lean *et al.* 1995; Lean *et al.* 1998; Pouliot *et al.* 1994). Moreover, in

the current NICE guidance (2006a), assessment of the health risk associated with overweight and obesity should be based on both BMI and waist circumference was also suggested. In addition to the available data collection, we analysed obesity on the basis of these three measurements. Because of the similarity patterns, the following sections will discuss BMI, waist circumference and WHR together. It is of note, however, that there were slight differences between the three adiposity measures. BMI was higher in the two most deprived groups, whereas waist circumference is likely to be more significantly larger in the three most deprived groups, and WHR is only lower in the least deprived group.

The findings of the current study agree with the existing studies in that people in the most deprived area are more likely to be obese by using measurement of BMI. Using professional classification, Emberson *et al.* (2004) found that BMI was higher in manual than non-manual UK workers. Puslaw (2008) found that higher BMI values with decreasing professional classifications. Stafford and colleagues (2010) found that residence in a more deprived neighbourhood contributed to a higher initial BMI when the study started. There was also a note that in this longitudinal, multilevel Whitehall II study of 13 years follow-up using Townsend index of multiple deprivation at census-ward level, participants from the most-deprived neighbourhoods experienced relatively greater weight gain over time, an increase of 1.5kg/m² in men and 1.4kg/m² in women.

Wang *et al.* (2007) gathered five cross-sectional surveys conducted by the Stanford Heart Disease Prevention Programme between 1979 and 1990 and found that participants from low socioeconomic neighbourhoods had a higher mean BMI than those from high socioeconomic neighbourhoods, after adjusting for age, sex, ethnicity, individual-level socioeconomic status, smoking, physical activity and nutrition knowledge. Similar finding has also been demonstrated in the GLOBE study (van Lenthe and Mackenbach 2002) with odds ratios of BMI increasing significantly with increasing neighbourhood deprivation, after adjusting for sex. Dragano *et al.* (2005) found that people having the least education were twice as likely to be obese than the most educated in Czech Republic and that this ratio was 1.6 in Germany. A Dutch study conducted by Han *et al.* (1998) suggested that large waist circumference was significantly associated with unemployment and lower education.

The same pattern was observed as in most other national and international studies. This study is confirmatory, but may not explain fully why such an association exists. Some studies have found that there are more fast-food outlets per capita and fewer healthy food stores per capita in the most deprived compared with least deprived areas, although the evidence is not consistent across all countries (Cummins and Macintyre 2002; Li *et al.* 2008; Li *et al.* 2009; Li *et al.* 2009; Mehta *et al.* 2008; Mhjahid *et al.* 2008; Rundle *et al.* 2009). Deprived areas often offered fewer opportunities for physical activity in the community (Boehmer *et al.* 2007; Frank *et al.* 2004; Frank *et al.* 2009; Hoehner *et al.* 2005; Li *et al.* 2008; Mhjahid *et al.* 2008; Rundle *et al.* 2009; Santos *et al.* 2008). There may also be socialisation effects stemming from the transmission of norms and behaviors associated with overweight and obesity that may differ between most deprived and least deprived areas (McLaren and Gauvin 2002).

5.4.3 Blood pressure

Given the confirmatory nature of the present data regarding the association between obesity and deprivation, it was expected that the related risk factor of blood pressure would be elevated in a similar, graded manner with deprivation. The data did not support this hypothesis, however, and despite elevated adiposity, neither blood pressure measures were significantly more likely to suggest hypertension in the most deprived groups. Paradoxically, it appears from the present data, being in the most deprived group was a significant predictor of having a more healthy blood pressure reading.

This association is more in line with the direction seen in the developing countries. Fernald and Adler (2008) conducted a house-to-house cross sectional survey in women aged 18-65 years old in Mexico. They found that two indicators of socioeconomic deprivation—educational attainment and working outside the home—showed an inverse association with systolic blood pressure. Similar findings have also been found in a multicentre collaborative study of risk factors for cardiovascular disease in the International Clinical Epidemiology Network (INCLEN). Nogueira *et al.* (1994) examined the relationship between cardiovascular risk factors and socio-economic variables in 12 centres in 7 countries—three in Thailand, two each in China, Chile and Brazil and one each in the Philippines, Indonesia and Colombia. They investigated approximately 200 men aged 35-65 drawn at random from a population within

their locality and found that among five Latin America countries, three showed a negative association between socioeconomic status and systolic blood pressure, and others showed no association. In a study of hypertension in an urban working population in Ghana the results showed a prevalence of hypertension in participants of lower socioeconomic status and a highest prevalence in those of the highest socioeconomic status (Addo 2009). There were suggestions of a negative association between the level of education and hypertension after adjusting for the other measures of socioeconomic status.

Our data are in contrast with much of the previous work conducted in developed countries. In a review of published literature to assess the association between socioeconomic status and blood pressure, high mean blood pressure or prevalence of hypertension was associated with low socioeconomic status in almost all studies from North America and most from Europe, regardless of the measure of socioeconomic status used (Colhoun *et al.* 1998). In the Whitehall study of London-based civil servants, mean BP and prevalence of hypertension were higher among men in the lower grades of employment (Marmot 1985). Hart and colleagues (2000) also found that the hazard ratio of higher risk of blood pressure in adults in the most deprived areas compared with those in the least deprived areas. In a study from developing countries, Cubbin *et al.* (2001) noted that blood pressure was higher in the most deprived areas than the least deprived areas among African women.

It is difficult to explain why the findings were different from other developed countries, but consistent with the findings from developing countries. The explanations could be the use of small non-representative samples, a variety of design flaws, the use of different measures of health outcomes and the measurement of socioeconomic status. A recent study (Perova *et al.* 2001) has shown mixed results, which may be due to methodological differences, heterogeneity of samples or differences in the degree of economic development.

5.4.4 Plasma cholesterol

Like blood pressure, plasma cholesterol is a risk factor often associated with increased adiposity. In this study, participants from the least deprived areas had less favourable serum lipids compared with those individuals from the most deprived areas. However, both total

cholesterol and low-density lipoprotein cholesterol measures were significantly lower in the most deprived groups. Indeed it appears from the present data, being in the most deprived group was a significant predictor of having a more healthy plasma lipid reading.

For total cholesterol, our data agreed with a study of 2682 Finnish men in the Kuopio ischaemic heart disease risk factor study (KIHD). Using educational levels as a measure of socioeconomic status, Lynch *et al.* (2006) found that total cholesterol were significantly higher for those who only attended primary school than those who are high school graduates in Finland. In the Puerto Rico Heart Programme, Sorlie and Garcia-Palmieri (1990) found that the mean values for serum cholesterol increased steadily with education indicating a cholesterol level of approximately 29 mg/dl (0.75mmol/l) lower for those with no education compared to those at the highest level in the urban area. This is in contrast to a study conducted in a Chinese urban population of 4,506 by Yu *et al.* (2001), who found that men in higher socioeconomic status had significantly higher total cholesterol compared with men in low socioeconomic status. This contrasting finding is consistent with previous Chinese studies (Siegrist *et al.* 1990; Tian *et al.* 1995) and other studies carried out in developing countries (Bunker *et al.* 1996; Pereira *et al.* 1998; Sorlie *et al.* 1990).

The contrasting findings were also found in other developed countries. Choiniere *et al.* (2000) used the Canadian Heart Health Surveys Database to analyse a probability sample of 29855 men and women aged 18-74 years old. Using educational level as a measure of socioeconomic status, they found that men and women with a university degree were less likely to have an elevated cholesterol level than those with no university degree. This situation appeared to be in contrast to those reported in the developing countries (Bennett 1995; Kaplan and Keil 1993; Winkleby *et al.* 1992). However, Lyratzopoulos and colleague (2007) found that deprivation status did not influence change in total cholesterol.

For HDL, our findings did not agree with existing literature. In two Chinese studies however, the authors found that men in the lower socioeconomic status had significantly higher HDL compared with men in higher socioeconomic status (Siegrist *et al.* 1990; Yu *et al.* 2001). The similar findings of Winkleby *et al.* (1992), showed that higher HDL was found in the highest socioeconomic groups. But Lynch *et al.* (2006) found that HDL was higher in the people who had only primary education compared with those who were high school graduate. Pereira *et al.*

(1998) also conducted a study in a population who are 25-74 years old in Mauritius. Using occupation as a measure of socioeconomic status, they found that HDL was higher in unskilled workers than professional/skilled workers. Also to note that females were five times less likely than males to have lower HDL.

LDL cholesterol had a similar pattern to total cholesterol. Our findings agree with several Chinese studies (Siegrist *et al.* 1990; Tian *et al.* 1995; Yu *et al.* 2001), which found that men in higher socioeconomic status had significantly higher LDL compared with men in low socioeconomic status. Pereira *et al.* (1998) also reported that LDL was lower in unskilled workers than professional/skilled workers. Using educational levels as a measure of socioeconomic status, Lynch *et al.* (2006) found that LDL were significantly higher for those only attending primary school compared with those who are high school graduate. In contrast, Larranaga *et al.* (2005) found that adults of lower socioeconomic status attending primary care clinics in the Basque region of Spain were found to have higher LDL compared with those of higher socioeconomic status. Moreover, females were two times less likely than males to have higher LDL.

A few studies have also reported that cholesterol increases as the level of socioeconomic deprivation level increases due to the reduction of intake of saturated fats, lower alcohol consumption, and consumption of more fruit, vegetables and whole grains (Briefel and Johnson 2004; Kanjilal *et al.* 2006; Marmot *et al.* 1991; McFadden *et al.* 2009; Popkin *et al.* 1996).

5.4.5 Strengths and limitations of the current study

The study is one of the first largest datasets on deprivation indices with this number of risk factors in the private medical care setting. As the dataset was obtained from a private healthcare company, it means that most participants were employed and able to afford private health screening. Therefore, our results might be different from other studies that used samples obtained from the National Health Services (NHS) in the UK. As NHS is free at the point of access, poorer economic circumstances should not in themselves be barriers to obtaining specialist care. Patients who attend the NHS primary care clinics may not be typical of the socioeconomic profile of its specific area because of variations in healthcare-seeking behaviour

or general practitioner referral patterns (Stewart *et al.* 2009). People who attended Nuffield Health are more likely to be of higher socioeconomic class due to the requirement to pay for this service. However, it is possible to compare the population who attended Nuffield Health with those located in a relatively affluent England region in terms of socioeconomic status, and validate these findings. The south central England region is relatively affluent compared with the national average. Therefore, in Chapter 8, we aim to examine the association between area-level deprivation and objectively measured, modifiable cardiovascular risk factors in a socioeconomic affluent population who attended the public NHS (dataset provided by the Hampshire Health Record), and then to compare the findings with those of this Chapter.

The number of people covered by private medical insurance rose to over six million in 2008, according to figures from the Association of British Insurers (2009), and an increasing number of those included in our dataset will be those employed in all sectors of the workforce from manual to management. Our results may be generalisable to other commercially insured populations. The benefit of this study is that the data were collected from different areas across the UK, and the study is larger than published work on deprivation indices with this number of risk factors in the primary care setting. Although many studies have assessed the association between socioeconomic status and cardiovascular risk factors, those studies were on the basis of much smaller sample size than was used in this study. This means that the results are not as valid and generalisable as this study.

There are many ways to measure deprivation, affluence or socioeconomic status within populations including: levels of education (Bhopal *et al.* 2002; Dragano *et al.* 2005), social class (Embason *et al.* 2004; Purslow *et al.* 2008; Starr and Deary 2010), income (Harrington and Elliott 2008; Lawlor *et al.* 2005), multiple indicators (Addo *et al.* 2009; Khan *et al.* 2006; Yu *et al.* 2002), area-level indices including multiple indices (Chen and Tunstall-Pedoe 2005; Lyratzopoulos *et al.* 2006; Stewart *et al.* 2009; Sundquist *et al.* 2004; van Lenthe and Mackenbach 2002). Previous work using area-level deprivation indices from the UK has demonstrated an association between deprivation and poor health outcomes at an individual level (Carstairs 1995; Woodward 1996). Area of residence is a determinant of cardiovascular risk, independently and additional to the effect of individually measured socioeconomic status (Shohaimi *et al.* 2003; Sundquist *et al.* 2004).

The present study used the English Indices of Deprivation 2007 because the advantages of postcode estimates served various epidemiological purposes. This was particularly when it was not feasible to collect detailed information on socioeconomic status due to large sample size. The smaller area level displays greater variation in many characteristics and provides a more sensitive basis for the identification of need and delivery of care than the health district. Therefore, an area measure of socioeconomic position could be used to help standardise for the health effects, which is important when the occurrence of a disease and associated risk factors are both related to poverty (Danesh *et al.* 1999). It has been used not only by health researchers to make more detailed measurements of socioeconomic status in a subset of participants, but also by the government for the last 10 years to identify and target areas of concentrated deprivation—important in directing significant levels of government funding and resources, both for regeneration and other programmes. Although the data used in this analysis are derived from a large and generally well maintained database, incomplete ascertainment of certain risk factors and the potential for errors in risk measurement arising from the non-research design of the database are acknowledged.

Another limitation of this study is the dataset does not include a history of medication. Use of lipid lowering drugs, primarily statin therapy, is recommended for patients with clinical evidence of cardiovascular disease. However, as this is a private medical insurance company, it only has limited data resources, because participants will still see their general practitioners (GP) to prescribe medication. Therefore, it is hard to know if participants' blood pressure and cholesterol level were drug controlled. Also, the present study did not measure habitual physical activity but it may be that more deprived participants were more active than those in the least deprived groups.

5.5 CONCLUSIONS

In conclusion, in this retrospective study of 55,217 participants attending Nuffield Health, findings showed that there is an association between socioeconomic deprivation and cardiovascular risk factors, especially strong links in obesity and lipids. People from the most deprived areas in this affluent population are more likely to be obese than those from the least deprived areas, but less likely to have higher total cholesterol and LDL. In this affluent population, individuals in the most deprived areas remain to be a target population for

prevention of obesity, but people from the least deprived areas should be targeted for total and LDL cholesterol check. The distribution of the pattern on cardiovascular risk factors in this affluent population is consistent with the distribution of cardiovascular risk factors in the general population. Regional preventive policy should focus on these higher prevalent cardiovascular risk factors. Physical activity should be a public health priority to improve cardiovascular health.

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CHAPTER 6:

GEOGRAPHICAL VARIATIONS IN MODIFIABLE CARDIOVASCULAR RISK FACTORS IN PEOPLE ATTENDING PRIVATE MEDICAL SCREENINGS

Abstract

Aim: Modifiable cardiovascular risk factors vary in prevalence across the UK. This chapter investigates geographical variations in modifiable cardiovascular risk factors in people attending private health screenings.

Methods: A retrospective study of over 50 000 participants from all regions in England was conducted using a dataset provided by a private healthcare company. Seven risk factors were analysed: body-mass index (BMI), waist circumference, waist-to-hip ratio (WHR), hypertension, total cholesterol, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol, selected from an extensive dataset including over 50 health variables. The English Indices of Deprivation 2007 scale was used to assign deprivation values to nine English regions.

Results: The absolute differences in various cardiovascular risk factors between regions were small, but some interesting statistically significant regional differences were apparent. Both men and women in Southern England were less likely to be obese than those in other regions in England. Participants in the South East (odds ratio [OR] 1.84, 95% CI 1.73–1.97, $p=0.000$), the West Midlands (OR 1.69, 95% CI 1.55–1.85, $p=0.000$), and the North West (OR 1.63, 95% CI 1.49–1.79, $p=0.000$) were much more likely to have high blood pressure than those from other regions. Men were twice as likely as women to be hypertensive across all regions in England (OR 2.18, 95% CI 2.08–2.29, $p=0.000$). Plasma cholesterol levels varied by region—participants in the North East had the highest risk of elevated total cholesterol, and those in the North West had the lowest risk; both men and women in the Midlands were less likely to have low HDL cholesterol than those in other regions in England; and participants in the North were less likely to have low LDL cholesterol than those in other regions. Because the primary focus of the Health Survey England (HSE) 2006 was cardiovascular disease, and

the prevalence of several modifiable risk factors—BMI, waist circumference, total cholesterol, HDL cholesterol, and hypertension—were investigated in this survey. Therefore, a comparison between the data from HSE 2006 and Nuffield Health dataset was conducted. Overall, the prevalence of most modifiable cardiovascular risk factors was higher in HSE 2006 data than in Nuffield Health data for both men and women across all regions in England. For men, the prevalence of overweight, raised waist circumference, and raised total cholesterol were higher in Nuffield Health data than in HSE data. Men in London were generally healthier than in other regions in England. Differences in prevalence of several risk factors were wide between regions, such as raised waist circumference (up to two times), low HDL (over three times), and hypertension (about two times). For women, the prevalence of obesity, raised waist circumference, and hypertension were much lower in the Nuffield Health data than in HSE 2006 data. Only the difference in prevalence of hypertension was wide between regions (more than two times).

Discussion: Geographical variations in the prevalence of modifiable cardiovascular risk factors have been reported both between and within countries. In general, participants from London were much healthier than those from other regions. Men from the Midlands, and especially those from the East Midlands, had relatively worse health conditions than those from other regions, so did women from the Midlands. Interestingly, women from South England had similar health conditions to those from the Midlands. Participants in the East Midlands and North West regions had a much higher risk of obesity than those from most other regions. Participants in the South East had the highest risk, and those in York & The Humber the lowest risk, of being hypertensive. In terms of plasma cholesterol measures, the distribution among regions seemed variable—participants in the North East had the highest risk of elevated total cholesterol, and those in the North West had the lowest risk; both men and women in the Midlands were less likely to have low HDL cholesterol than those in other regions in England; and participants in North England were less likely to have high LDL cholesterol than those in other regions in England. The variation in cardiovascular risk factors can be explained by difference in dietary consumption of fats, sugars, and green, leafy vegetables. However, a North-South (Scottish) effect was not seen in the current study. The reason could be the study population in the present study, which was an affluent group. We could speculate that this effect might be able to be seen in the same population in other countries in Europe.

Conclusion: Clear regional differences exist for cardiovascular risk factors: participants from London had the lowest cardiovascular risks compared with those from all other regions in the analysis. This is one of the first studies to show regional differences in cardiovascular risk factors across England with such a high number of risk factors and other variables in a primary care setting, but was restricted to participants with private medical insurance.

6.1 INTRODUCTION

Geographical variations in cardiovascular disease and associated risk factors have been identified and reported in a range of European countries on the basis of both prevalence and incidence. Sans and colleagues (1997) analysed regional data for European countries submitted to the World Health Organization (WHO), and reported a clear north–east to south–west gradient in cardiovascular disease mortality. They noted that the lowest rates of mortality from cardiovascular disease for both men and women were in France, Spain, Switzerland, and Italy and the highest rates were observed in Central and Eastern European countries such as Ukraine, Bulgaria, and the Russian Federation. The effect of regional variation within countries varied. In Germany, 10 years after reunification, Müller-Nordhorn and colleagues (2004) concluded that mortality from ischaemic heart disease was still about 50% higher in East compared with West Germany. In the West, mortality from ischaemic heart disease continuously decreased throughout the 1990s, whereas in the East, mortality peaked during the early 1990s, and is now declining gradually. In France, mortality from ischaemic heart disease showed a north–south gradient (Lang *et al.* 1999).

The current European Guidelines on Cardiovascular Disease Prevention in Clinical Practice take national variation in cardiovascular mortality into consideration (De Backer *et al.* 2003). In the primary prevention setting, the overall 10-year cardiovascular risk is estimated for different combinations of risk factors. The assessment of cardiovascular risk takes the following risk factors into consideration: age, sex, smoking, systolic blood pressure (SBP), and cholesterol. An increased risk greater than 5% of a fatal cardiovascular event in the next 10 years should lead to increased preventive efforts including lifestyle changes and medication. In the guidelines, the use of two different risk assessment charts is recommended: one for countries with high risk and one for countries with low risk. On the basis of several cohort studies assessing cardiovascular risk, countries with a low risk are Belgium, France, Greece, Italy, Luxembourg, Spain, Switzerland, and Portugal, with all other European countries classified as high risk.

In the UK, many studies have shown that mortality and morbidity vary across both small and larger geographical areas (Boyle *et al.* 1999; Cliff *et al.* 1981; Shelton *et al.* 2007). Specifically, modifiable cardiovascular risk factors vary in prevalence across the UK. In England, for

example, this is exemplified at a regional level by a North–South gradient in prevalence of cardiovascular risk factors and health outcomes, with higher prevalence in the North (Doran *et al.* 2006). Furthermore, several studies have investigated the relationship between geographical variation and cardiovascular risk factors. The British Regional Heart Study (BRHS) showed that the North–South differences in cardiovascular disease incidence in men could be explained by classical risk factors such as smoking, physical activity, body-mass index (BMI), alcohol consumption, SBP, serum total cholesterol, occupational social class, and height. In women, differences in prevalence of cardiovascular disease across four broad regions of the UK (Scotland, North England, Midlands/Wales, and South England) were examined in the baseline survey of the British Women's Heart and Health Study (BWHHS). The highest prevalence of cardiovascular disease was reported in Scotland, and the lowest in South England. By contrast with findings in men drawn from the same geographical areas, this variation by region remained after adjustment for several cofactors such as age, SBP, diastolic blood pressure (DBP), total cholesterol, high-density-lipoprotein (HDL) cholesterol, smoking, physical activity, fruit consumption, social class, and use of aspirin or statins.

The Health Survey for England (HSE) is an annual health examination survey of a nationally-representative sample of the English population living in private households. It provides representative data on a broad range of health topics. Participants are visited by interviewers, who measure height and weight and collect household-level and individual-level data using computer-assisted personal interviews. Participants who agree to additional assessments are visited on a separate occasion by nurses, who obtain further measurements and biological samples. The interviewer's visit includes a short self-completion booklet, which includes questions about perceived social support and the General Health Questionnaire (GHQ12, a measure of psychological health) questions (DeLeeuw *et al.* 2003). The HSE 2006 report focused on cardiovascular disease and associated risk factors, which covered health-status risk factors including total cholesterol, HDL cholesterol, blood pressure, diabetes, and anthropometric measurements such as BMI and waist circumference.

Chapter 5 examined the association between area-level socioeconomic deprivation and objectively-measured, modifiable cardiovascular risk factors in a non-clinical UK population who attended private health screenings. The results showed that there is an association between socioeconomic deprivation and cardiovascular risk factors, with especially strong associations

for obesity and lipids. People from the most deprived areas are more likely to be obese than those from the least deprived areas, but are less likely to have raised total and LDL cholesterol. Although the prevalence of cardiovascular risk factors has been investigated at an area-level by socioeconomic status, there is still a need to investigate how cardiovascular risk factors are distributed at a national geographical level, since the occurrence of cardiovascular disease does vary geographically. Other established cohort studies—The Whitehall II, Renfrew-Paisley, Scottish Heart Health, and Glasgow Students studies (Hart *et al.* 1997; Hart *et al.* 1997; Marmot *et al.* 1991; McCarron *et al.* 1999)—have provided valuable aetiological insights and comparisons between women and men, but have limited national representativeness, and are unable to assess geographical variations because of their single locations. Also, although several studies have been conducted in the NHS and by public survey (Lawlor *et al.* 2003; HSE 2008; Shelton *et al.* 2007; Shelton 2009), no study has previously been done in a population of people with private medical insurance. An explanation for the regional variation remains unknown.

Better knowledge about regional variation of cardiovascular disease could lead to improved understanding disease aetiology, more appropriate for allocation of treatment resources in the health system. Therefore, the purpose of this study was to: (1) explore geographical variations in the prevalence of modifiable cardiovascular risk factors in people attending private health screenings in England; (2) compare the prevalence of modifiable cardiovascular risk factors from private medical screenings with the findings from the HSE 2006; and (3) estimate the risks of various modifiable cardiovascular risk factors at a regional level from dataset provided by the Nuffield Health.

6.2 METHODS

6.2.1 Study setting and data collection

Data were provided by a private healthcare company, Nuffield Health. The assessment programmes were delivered using a bespoke electronic patient record system developed exclusively for Nuffield Health—the Vi System. This system offered greater accuracy, and faster and more comprehensive reports than other systems, e.g. paper-based systems. It

provides instant comparison with previous test results and the ability for clients to use any of their centres in the UK to immediately access their records. Data were extracted from the records of the Nuffield Health. Aggregate data provided by the Nuffield Health were anonymised, in line with the Information Commissioner Office's (2013) anonymisation code, it can be freely processed and publicly disclosed. Data were recorded for participants during screenings for provision of employment-related medical care. At each of the company's testing sites, data were collected by trained health professionals using protocols consistent with the British Hypertension Society for blood pressure and blood analysis, and the American College of Sports Medicine for anthropometry.

6.2.2 Individual-level cardiovascular risk factors

Several established cardiovascular risk factors represented the risk profile of the participants: (1) anthropometric characteristics—BMI, waist-to-hip ratio (WHR), and waist circumference. Obesity was examined by BMI, WHR, and waist circumference, separately. Normal weight was defined as a BMI between 18.5 and 25 kg/m²; overweight was defined as a BMI between 25 and 30 kg/m²; obesity was defined as a BMI between 30 and 40 kg/m²; and morbid obesity was defined as a BMI over 40 kg/m² (WHO 2005; NICE 2006). Waist circumference was measured at the anatomical waist; central obesity was defined as greater than 102cm in men and greater than 88 cm in women. The waist-to-hip ratio was defined as high if values were greater than 0.95 in men and greater than 0.80 in women (Croft *et al.* 1995). (2) Blood pressure. Hypertension was classified as DBP greater than 90 mm Hg (DBP) or SBP greater than 140 mm Hg (NICE 2006). (3) Plasma serum. Plasma serum measures include total, HDL, and LDL cholesterol. Arterial blood was drawn and analysed, with measurements of total cholesterol, LDL subfraction, and HDL subfraction. Total cholesterol was classified as raised if higher than 6.0 mmol/L. HDL was classified as low if less than 1.0 mmol/L; LDL was classified as raised if greater than 3.36 mmol/L (Contois *et al.* 1996).

Age and sex were adjusted for in multinomial and binary logistic regression analyses. Age was defined as a continuous variable.

6.2.3 Geographical variations

The National Statistics Postcode Directory (NSPD) (National Statistics 2007) is a list of all the current and terminated postcodes that have ever existed in the UK, together with geographical links or matches for each postcode to a variety of different administrative, health, electoral, and other areas that are, or have been, used within the UK. The information contained within the NSPD has a wide range of potential uses across a broad range of disciplines wherever postcode data are used, or where information on the relationships between different geographies, or changes in a single geography over time, is required. GeoConvert (GeoConvert 2007) is an online service available from the Census Dissemination Unit. It uses information from the NSPD to perform a variety of functions. Geoconvert was used to convert postcodes to different geographical regions—North East, North West, Yorkshire & The Humber, East Midlands, West Midlands, East of England, London, South East, South West, Scotland, Wales, Northern Ireland, Isle of Man, and Isle of Wight.

6.2.4 Statistical Analysis

Descriptive statistics were generated. ANOVA was performed for mean values of each cardiovascular risk factor. Multinomial logistic regressions and binary logistic regression were both performed to investigate the effect of regional variation on various modifiable cardiovascular risk factors. The association between geographical variation and cardiovascular risk factors was evaluated by the ORs for regions alone (model 1), and after adjustment for age and sex (model 2). Both of adjusted and unadjusted results are compared in the statistical analysis. Data from this study were analysed with SPSS Version 17.0 (SPSS Inc., Chicago, IL, USA). All baseline data were analysed α at of 0.05 to determine statistical significance.

6.3 RESULTS

6.3.1 Geographical descriptive statistics for the Nuffield dataset in different measures

A retrospective population of 60,334 participants aged between 18 and 75 years across the UK was selected for analysis. Demographic and clinical characteristics of men and women in different geographical regions in the format of mean values with standard deviations are shown in Tables 6.1 and 6.2, respectively.

Table 6.1: Demographic and clinical characteristics of men in different geographical regions (mean and SD)

	BMI (kg/m ²)	Waist circumference	Waist-to-hip ratio	SBP	DBP	Total cholesterol	HDL	LDL
	(n=33552)	(n=33550)	(n=33550)	(n=33548)	(n=33548)	(n=27107)	(n=27099)	(n=26477)
North East	27.32 (3.59)	95.2 (10.1)	0.92 (0.061)	128.6 (13.3)	81.5 (8.8)	5.49 (1.03)	1.44 (0.39)	3.33 (0.95)
North West	27.28 (3.92)	95.6 (11.1)	0.91 (0.065)	126.4 (14.9)	81.5 (9.4)	5.37 (0.99)	1.41 (0.32)	3.23 (0.86)
Yorkshire & The Humber	27.66 (3.91)	94.0 (11.0)	0.90 (0.065)	124.8 (15.0)	79.9 (10.0)	5.47 (1.04)	1.37 (0.35)	3.41 (0.93)
East Midlands	27.49 (4.05)	96.6 (11.0)	0.92 (0.059)	128.5 (14.2)	82.2 (8.7)	5.44 (1.01)	1.31 (0.33)	3.45 (0.90)
West Midlands	27.39 (3.80)	94.8 (10.8)	0.91 (0.064)	129.2 (14.2)	82.9 (8.9)	5.43 (0.98)	1.33 (0.33)	3.40 (0.87)
East of England	27.12 (3.63)	93.5 (10.5)	0.91 (0.063)	126.4 (14.1)	81.0 (9.3)	5.42 (1.00)	1.35 (0.34)	3.39 (0.89)
London	26.21 (3.55)	90.7 (10.6)	0.88 (0.066)	122.7 (12.8)	79.5 (8.9)	5.23 (0.98)	1.44 (0.33)	3.15 (0.83)
South East	26.93 (3.66)	93.8 (10.5)	0.90 (0.064)	129.0 (14.5)	83.1 (9.6)	5.43 (1.01)	1.39 (0.36)	3.39 (0.90)
South West	27.24 (3.81)	95.4 (10.7)	0.92 (0.064)	129.6 (14.8)	81.2 (9.1)	5.46 (1.00)	1.39 (0.34)	3.39 (0.89)
Total	26.99 (3.76)	93.6 (10.8)	0.90 (0.065)	126.7 (14.3)	81.4 (9.3)	5.38 (1.00)	1.39 (0.34)	3.33 (0.89)

Table 6.2: Demographic and clinical characteristics of women in different geographical regions (mean and SD)

	BMI (kg/m ²)	Waist circumference	Waist-to-hip ratio	SBP	DBP	Total cholesterol	HDL	LDL
	(n=21551)	(n=17582)	(n=17582)	(n=21548)	(n=21550)	(n=18066)	(n=18065)	(n=18012)
North East	25.51 (4.86)	81.8 (12.1)	0.80 (0.065)	120.9 (14.5)	75.4 (8.9)	5.22 (1.05)	1.86 (0.49)	2.88 (0.92)
North West	25.34 (4.54)	82.7 (11.6)	0.80 (0.068)	118.0 (14.6)	75.3 (9.2)	5.05 (0.91)	1.74 (0.40)	2.83 (0.80)
Yorkshire & The Humber	25.79 (4.38)	80.5 (11.8)	0.79 (0.068)	117.3 (14.8)	75.0 (9.3)	5.23 (0.97)	1.77 (0.44)	2.99 (0.88)
East Midlands	25.38 (4.78)	82.3 (11.8)	0.81 (0.069)	122.3 (15.0)	76.7 (8.6)	5.30 (1.00)	1.70 (0.42)	3.13 (0.89)
West Midlands	25.59 (4.73)	82.1 (12.3)	0.80 (0.075)	121.9 (14.5)	77.6 (9.1)	5.14 (0.97)	1.65 (0.43)	3.02 (0.84)
East of England	25.36 (4.71)	80.2 (12.4)	0.79 (0.073)	118.8 (14.9)	75.6 (9.5)	5.20 (0.98)	1.74 (0.44)	3.00 (0.87)
London	24.20 (4.34)	78.5 (11.5)	0.79 (0.073)	114.1 (13.3)	73.7 (9.1)	4.93 (0.90)	1.77 (0.39)	2.72 (0.77)
South East	25.06 (4.66)	89.1 (12.9)	0.80 (0.074)	121.4 (15.4)	77.3 (10.0)	5.23 (1.00)	1.75 (0.45)	3.03 (0.90)
South West	25.20 (4.80)	90.5 (12.9)	0.80 (0.068)	122.7 (15.9)	76.2 (9.3)	5.33 (1.03)	1.76 (0.44)	3.10 (0.91)
Total	24.99 (4.60)	85.2 (13.4)	0.80 (0.072)	118.6 (14.9)	75.7 (9.5)	5.13 (0.97)	1.75 (0.42)	2.93 (0.86)

6.3.1.1 BMI

6.3.1.1.1 Men

Men in London had the lowest mean BMI, and those in Yorkshire & The Humber the highest (26.21 vs 27.66, $p < 0.001$). The lowest prevalence of overweight in men was in London, and the highest was in the East Midlands (47% vs 54%). Men in London also had the lowest prevalence of obesity, with the prevalence in Yorkshire & The Humber almost twice that in London (13% vs 23%).

6.3.1.1.2 Women

Women in London had the lowest mean BMI, and those in Yorkshire & The Humber the highest (24.20 vs 25.79, $p < 0.001$). The lowest prevalence of overweight was in London, and the highest was in Yorkshire & The Humber (23% vs 33%). Women in London also had the lowest prevalence of obesity, with the highest prevalence seen in two regions—Yorkshire & The Humber and the North East (10% vs 17%).

6.3.1.2 Waist circumference

6.3.1.2.1 Men

Men in London had the lowest mean waist circumference, and those in the East Midlands the highest (90.7 vs 96.6, $p < 0.001$). The lowest prevalence of raised waist circumference for men was in London, and the highest was in the East Midlands, where the prevalence was twice that of London (14% vs 28%).

6.3.1.2.2 Women

Women in London had the lowest mean waist circumference; and those in the South West the highest (78.5 vs 90.5, $p < 0.001$). The lowest prevalence of raised waist circumference was in London, and the highest was in the North West (20% vs 30%).

6.3.1.3 Waist-to-hip ratio

6.3.1.3.1 Men

Men in London had the lowest mean WHR, and the highest mean WHRs were in three regions—the North East, the East Midlands, and the South West (0.88 vs 0.92, $p < 0.001$). The lowest prevalence of raised WHR was in London, and the highest were in the North East and South West, which were both twice that of London (15% vs 30%).

6.3.1.3.2 Women

Women in Yorkshire & The Humber, the East of England, and London had the lowest mean WHR, and the East Midlands had the highest mean WHR (0.79 vs 0.81, $p < 0.001$). The lowest prevalence of raised WHR was in Yorkshire & The Humber, and the highest was in East Midlands (37% vs 53%).

6.3.1.4 Hypertension

6.3.1.4.1 Men

Men in London had the lowest mean SBP and DBP; the highest mean SBP was in the South West and the highest mean DBP was in the South East (SBP 122.7 vs 129.6, $p < 0.001$; DBP 79.5 vs 83.1, $p < 0.001$). The lowest prevalence of hypertension was in London, and the highest was in the South East (16% vs 31%).

6.3.1.4.2 Women

Women in London had the lowest mean SBP and DBP; the highest mean SBP was in the South West and the highest mean DBP was in the West Midlands (SBP 114.1 vs 122.7, $p < 0.001$; DBP 73.7 vs 77.6, $p < 0.001$). The lowest prevalence of hypertension was in London, and the highest were in the South East and South West (7% vs 17%).

6.3.1.5 Total cholesterol

6.3.1.5.1 Men

Men in London had the lowest mean total cholesterol, and those in the North East the highest (5.23 vs 5.49, $p < 0.001$). The lowest prevalence of raised cholesterol was in London, and the highest was in the North East (60% vs 72%).

6.3.1.5.2 Women

Women in London had the lowest mean total cholesterol, and those in the South West the highest (4.93 vs 5.33, $p<0.001$). The lowest prevalence of raised cholesterol was in London, and the highest was in the South West (46% vs 62%).

6.3.1.6 HDL cholesterol

6.3.1.6.1 Men

Men in London had the highest mean HDL cholesterol, and those in the East Midlands the lowest (1.44 vs 1.31, $p<0.001$). The lowest prevalence of low HDL cholesterol was in London, and the highest was in the East Midlands (4.6% vs 13.4%).

6.3.1.6.2 Women

Women in London had the highest mean HDL cholesterol, and those in the East Midlands the lowest (1.77 vs 1.65, $p<0.001$). The lowest prevalence of low HDL cholesterol was in London, and the highest was in the West Midlands (0.8% vs 2.1%).

6.3.1.7 LDL cholesterol

6.3.1.7.1 Men

Men in London had the lowest mean LDL cholesterol, and those in the East Midlands the highest (3.15 vs 3.45, $p<0.001$). The lowest prevalence of raised LDL cholesterol was in London, and the highest was in the East Midlands (39% vs 53%).

6.3.1.7.2 Women

Women in London had the lowest mean LDL cholesterol, and those in the East Midlands the highest (2.72 vs 3.13, $p<0.001$). The lowest prevalence of raised LDL cholesterol was in London, and the highest was in the East Midlands (19% vs 38%).

Overall, both men and women from London were much healthier than those from other regions. Men from the Midlands, especially the East Midlands, had relatively worse health conditions. Women from the Midlands also had relatively worse health conditions. Interestingly, women from South England had similar health conditions to those from the Midlands (with more than five risk factors up to high likelihood of risk).

6.3.2 Risk estimates for the modifiable cardiovascular risk factors in the Nuffield dataset

Age and sex are non-modifiable risk factors. They have, therefore been adjusted for, with the significance of age and sex for each risk factor shown (Tables 6.3, 6.4, and 6.5).

Table 6.3: Anthropometric characteristics (BMI, waist circumference, and WHR) after adjusted for age, sex and geographical regions (odds ratio and 95% CI)

Risk factors	Number of people	Model	
		Odds ratio (95% CI)	p value
Body-mass index (overweight)			
Government Office Regions			
London	5669	1.00	
North East	572	0.81 (0.66-0.99)	0.04
North West	1827	1.06 (0.84-1.35)	0.60
Yorkshire & The Humber	1313	1.14 (0.92-1.40)	0.23
East Midlands	1126	1.29 (1.04-1.60)	0.019
West Midlands	1880	1.11 (0.89-1.38)	0.34
East of England	2739	1.15 (0.93-1.42)	0.19
South East	5639	1.02 (0.83-1.26)	0.81
South West	2089	0.92 (0.75-1.13)	0.42
Sex			
Male		3.27 (3.15-3.40)	0.000
Female		1.00	
Age		1.029 (1.027–1.031)	0.000
Body mass index (obese)			
Government Office Regions			
London	1746	1.00	
North East	236	0.59 (0.46-0.76)	0.000
North West	765	1.01 (0.75-1.35)	0.96
Yorkshire & The Humber	605	1.10 (0.85-1.44)	0.46
East Midlands	461	1.38 (1.05-1.80)	0.02
West Midlands	792	1.04 (0.88-1.51)	0.29
East of England	1167	1.10 (0.85-1.44)	0.46
South East	2155	1.00 (0.77-1.30)	0.99
South West	812	0.80 (0.62-1.03)	0.09
Sex			
Male		2.50 (2.37-2.62)	0.000
Female		1.00	
Age		1.036 (1.034–1.038)	0.000
Waist circumference (obese)			
Government Office Regions			
London	2283	1.00	
North East	298	1.39 (1.20-1.60)	0.000
North West	1097	1.78 (1.64-1.94)	0.000
Yorkshire & The Humber	632	1.32 (1.20-1.47)	0.000
East Midlands	645	1.67 (1.51-1.85)	0.000
West Midlands	997	1.45 (1.33-1.48)	0.000
East of England	1271	1.19 (1.10-1.29)	0.000
South East	2800	1.24 (1.17-1.32)	0.000
South West	1114	1.28 (1.18-1.39)	0.000

Sex			
Male		0.73 (0.70-0.76)	0.000
Female		1.00	
Age		1.035 (1.034–1.037)	0.000
Waist-to-hip ratio (WHR) (obese)			
Government Office Regions			
London	3418	1.00	
North East	411	1.35 (1.18-1.54)	0.000
North West	1338	1.45 (1.34-1.57)	0.000
Yorkshire & The Humber	746	0.99 (0.90-1.09)	0.81
East Midlands	826	1.50 (1.36-1.66)	0.000
West Midlands	1310	1.27 (1.17-1.38)	0.000
East of England	1788	1.14 (1.06-1.22)	0.001
South East	3786	1.11 (1.05-1.17)	0.001
South West	1604	1.24 (1.14-1.34)	0.000
Sex			
Male		0.30 (0.29-0.31)	0.000
Female		1.00	
Age		1.053 (1.051–1.055)	0.000

Table 6.4: Hypertension (SBP >140 mm Hg or DBP >90 mm Hg) after adjusted for age, sex and geographical regions (odds ratio and 95% CI)

Risk factors	Number of people	Model	
		Odds ratio (95% CI)	p value
Hypertension (SBP>90 mm Hg or DBP>140 mm Hg)			
Government Office Regions			
London	1809	1.00	
North East	273	1.32 (1.14-1.53)	0.000
North West	875	1.63 (1.49-1.79)	0.000
Yorkshire & The Humber	526	1.20 (1.07-1.34)	0.001
East Midlands	543	1.39 (1.24-1.56)	0.000
West Midlands	1016	1.69 (1.55-1.85)	0.000
East of England	1270	1.33 (1.23-1.45)	0.000
South East	3407	1.84 (1.73-1.97)	0.000
South West	1140	1.45 (1.33-1.59)	0.000
Sex			
Male		2.18 (2.08-2.29)	0.000
Female		1.00	
Age		1.057 (1.055–1.059)	0.000

Table 6.5: Plasma cholesterol (total cholesterol, HDL cholesterol, and LDL cholesterol) after adjusted for age, sex and geographical regions (odds ratio and 95% CI)

Risk factors	Number of people	Model	
		Odds ratio (95% CI)	p value
Elevated total cholesterol			
Government Office Regions			
London	6133	1.00	
North East	731	1.32 (1.15-1.51)	0.000
North West	1786	1.08 (0.99-1.18)	0.07
Yorkshire & The Humber	1601	1.28 (1.16-1.40)	0.000
East Midlands	1449	1.23 (1.12-1.36)	0.000
West Midlands	2335	1.17 (1.08-1.26)	0.000
East of England	3389	1.18 (1.10-1.26)	0.000
South East	7194	1.19 (1.13-1.26)	0.000
South West	2899	1.23 (1.14-1.33)	0.000
Sex			
Male		1.43 (1.38-1.49)	0.000
Female		1.00	
Age		1.046 (1.044-1.048)	0.000
Low HDL cholesterol			
Government Office Regions			
London	326	1.00	
North East	60	0.56 (0.42-0.74)	0.000
North West	88	0.95 (0.75-1.21)	0.69
Yorkshire & The Humber	158	0.47 (0.39-0.58)	0.000
East Midlands	208	0.31 (0.26-0.37)	0.000
West Midlands	276	0.38 (0.32-0.45)	0.000
East of England	376	0.41 (0.35-0.48)	0.000
South East	619	0.53 (0.46-0.61)	0.000
South West	218	0.59 (0.49-0.70)	0.000
Sex			
Male		0.14 (0.12-0.16)	0.000
Female		1.00	
Age		1.007 (1.003-1.011)	0.001
High LDL cholesterol			
Government Office Regions			
London	3375	1.00	
North East	446	1.26 (1.10-1.44)	0.001
North West	1067	1.14 (1.04-1.24)	0.004
Yorkshire & The Humber	1075	1.52 (1.38-1.66)	0.000
East Midlands	1039	1.67 (1.52-1.84)	0.000
West Midlands	1576	1.46 (1.35-1.59)	0.000
East of England	2291	1.47 (1.37-1.58)	0.000
South East	8055	1.44 (1.36-1.53)	0.000

South West	1960	1.48 (1.38-1.60)	0.000
Sex			
Male		2.05 (1.97-2.13)	0.000
Female		1.00	
Age		1.036 (1.034-1.038)	0.000

6.3.2.1 BMI

After adjustment for age and sex, the risk of being overweight (as defined by BMI) for participants in the North East was significantly lower than for those in London (OR 0.81, 95% CI 0.66–0.99 $p=0.04$). However, participants in the East Midlands had a significantly higher prospect of being overweight than those in London (OR 1.29, 95% CI 1.04–1.60, $p=0.019$). Across England, men were over three times more likely than women to be overweight (OR 3.27, 95% CI 3.15–3.40, $p<0.001$).

The pattern for BMI-defined obesity was similar to that for overweight. After adjustment for age and sex, the risk of being obese for participants in the North East was significantly lower than for those in London (OR 0.59, 95% CI 0.46–0.76 $p<0.001$). However, participants in the East Midlands had a significantly higher chance of being obese than those in London (OR 1.38, 95% CI 1.05–1.80, $p=0.02$). Across the whole of England, men were 2.5 times more likely than women to be overweight (OR 2.50, 95% CI 2.37–2.62, $p<0.001$).

6.3.2.2 Waist circumference

Compared with participants in London, those in all other regions were significantly more likely to be obese (as defined by waist circumference), after adjustment for age and sex. Participants from the North West (OR 1.78, 95% CI 1.64–1.94, $p<0.001$) and the East Midlands (OR 1.67, 95% CI 1.51–1.85, $p<0.001$) were much likely to be obese (defined by waist circumference) than those from other regions. Men were less likely than women to be defined as obese on the basis of waist circumference (OR 0.73, 95% CI 0.70–0.76, $p<0.001$).

6.3.2.3 Waist-to-hip ratio

Compared with participants in London, those in other regions were more likely to be obese (as defined by WHR), and these differences were statistically significant for all regions apart from Yorkshire & The Humber (OR 0.99, 95% CI 0.90–1.09, $p=0.81$), after adjustment for age and sex. Participants in the East Midlands were most likely to have the highest WHR, with an OR of 1.50 (95% CI 1.36–1.66, $p<0.001$). Men were less likely than women to be obese on the basis of WHR (OR 0.30, 95% CI 0.29–0.31, $p<0.001$).

6.3.2.4 Hypertension

Compared with participants in London, those in other regions were significantly more likely to be hypertensive after adjustment for age and sex. Participants in the South East (1.84, 95% CI 1.73–1.97, $p<0.001$), the West Midlands (1.69, 95% CI 1.55–1.85, $p<0.001$), and the North West (1.63, 95% CI 1.49–1.79, $p<0.001$) were much likely to have high blood pressure than those from other regions. Men were twice as likely as women to be hypertensive (2.18, 95% CI 2.08–2.29, $p<0.001$).

6.3.2.5 Total cholesterol

Compared with participants in London, those in other regions were more likely to have elevated total cholesterol, and these differences were statistically significant for all regions apart from the North West (OR 1.08, 95% CI 0.99–1.18, $p=0.07$), after adjusting for age and sex. Participants in the North East were most likely to have the highest total cholesterol, with an OR of 1.32 (95% CI 1.15–1.51, $p<0.001$). Men were more likely than women to have elevated total cholesterol (OR 1.43, 95% CI 1.38–1.49, $p<0.001$).

6.3.2.6 HDL cholesterol

Compared with participants in London, those in other regions were more likely to have low HDL cholesterol, and the increased odds were statistically significant for all regions apart from the North West (OR 0.95, 95% CI 0.75–1.21, $p=0.69$), after adjustment for age and sex.

Participants in the East Midlands were the least likely to have low HDL cholesterol, with an OR of 0.31 (95% CI 0.26–0.37, $p<0.001$). Participants in the West Midlands (OR 0.38, 95% CI 0.32–0.45, $p<0.001$) and the East of England (OR 0.41, 95% CI 0.35–0.48, $p<0.001$) were the next least likely to have low HDL cholesterol. Men were much less likely than women to have low HDL cholesterol (OR 0.14, 95% CI 0.12–0.16, $p<0.001$).

6.3.2.7 LDL cholesterol

Compared with participants in London, those in all other regions were significantly more likely to have raised LDL cholesterol, after adjustment for age and sex. Participants from the East Midlands (OR 1.67, 95% CI 1.52–1.84, $p<0.001$) and Yorkshire & The Humber (OR 1.52, 95% CI 1.38–1.66, $p<0.001$) were the most likely to have raised LDL cholesterol. Men were twice as likely as women to have raised LDL cholesterol (OR 2.05, 95% CI 1.97–2.13, $p<0.001$).

6.3.3 Comparison of prevalence of modifiable cardiovascular risk factors between the Nuffield dataset and the Health Survey for England 2006

There were two reasons to compare the results from Nuffield Health with HSE 2006. First, the primary focus of HSE 2006 was cardiovascular disease, and the prevalence of several modifiable risk factors in different regions in England included in this survey—BMI, waist circumference, total cholesterol, HDL cholesterol, and hypertension—were also investigated in Nuffield Health dataset. Second, HSE 2006 provided data from nationally representative samples to monitor trends in England—a total of 14,142 adults from 14,400 addresses (data for 3491 children were reported separately) were selected, and households were sampled proportionately across the nine Government Office regions of England. The differences between the results of data from HSE 2006 and the Nuffield Health dataset are shown in tables 6.6 and 6.7.

Table 6.6: Comparison of a list of modifiable cardiovascular risk factors between HSE 2006 and the Nuffield data in men by Government Office Regions

Risk factors GOR	Overweight (%)		Obese (%)		Raised waist circumference (%)		Total cholesterol ≥ 5.0 mmol/l (%)		HDL cholesterol <1.0 mmol/l (%)		Hypertension (%)	
	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data
North East	35	53	28	20	32	24	59	72	9.4	7.9	35	26
North West	43	52	23	20	32	26	57	64	8.9	4.3	31	27
Yorkshire and The Humber	41	53	26	23	30	23	62	68	10.4	9.3	31	22
East Midlands	42	54	26	21	31	28	54	67	9.9	13.4	32	26
West Midlands	47	53	28	22	34	24	60	68	14.1	10.8	32	29
East of England	48	51	22	20	31	20	58	67	10.0	10.3	28	24
London	42	47	19	13	30	14	52	60	7.5	4.6	31	16
South East	46	50	20	20	31	21	59	68	8.7	8.2	26	31
South West	41	53	27	18	37	25	56	69	6.5	7.4	31	28

Table 6.7: Comparison of a list of modifiable cardiovascular risk factors between HSE 2006 and the Nuffield data in women by Government Office Regions

Risk factors GOR	Overweight (%)		Obese (%)		Raised waist circumference (%)		Total cholesterol ≥ 5.0 mmol/l (%)		HDL cholesterol <1.0 mmol/l (%)		Hypertension (%)	
	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data	Health Survey for England 2006	Nuffield data
North East	32	28	28	17	41	27	61	58	2.0	0.8	28	12
North West	33	29	21	15	37	30	61	52	1.9	0.6	27	10
Yorkshire and The Humber	32	33	25	17	39	24	61	58	1.3	1.0	30	11
East Midlands	34	29	26	15	41	28	60	61	0.6	1.4	29	14
West Midlands	33	32	30	15	42	28	60	54	1.8	2.1	25	15
East of England	36	28	23	16	44	24	61	56	2.0	1.6	23	13
London	28	23	21	10	40	20	58	46	2.6	0.8	24	7
South East	30	28	24	13	40	26	63	57	1.7	1.2	26	17
South West	34	29	23	14	45	25	66	62	1.9	1.1	27	17

6.3.3.1 BMI

6.3.3.1.1 Men

Compared with data collected from HSE 2006, the prevalence of BMI-defined overweight in men in the Nuffield Health dataset was higher in all regions. In the HSE 2006 data, the highest prevalence of overweight was in the East of England (48%), and lowest was in the North East (35%). In the Nuffield dataset, the highest prevalence was in the East Midlands (54%), and the lowest in London (47%).

The prevalence of obesity in men was much higher in HSE 2006 data than in the Nuffield Health data in all regions apart from the South East, where the prevalence was the same (19%). In the HSE 2006 data, the highest prevalence of obesity was in the North East and West Midlands (28%), and lowest was in London and North West (19%). In the Nuffield Health dataset, the highest prevalence was in Yorkshire & The Humber (23%), and the lowest was in London (13%).

6.3.3.1.2 Women

Compared with data collected from HSE 2006, the prevalence of BMI-defined overweight in women in the Nuffield Health dataset was lower in all regions apart from Yorkshire & The Humber, which was higher in Nuffield Health data (33% v3233%). In the HSE 2006 data, the highest prevalence of overweight was in the East of England (36%), and lowest was in London (28%). In the Nuffield dataset, the highest prevalence of overweight was in Yorkshire & The Humber (33%), and the lowest was in London (23%).

The prevalence of obesity in women was much higher in the HSE 2006 data than in the Nuffield Health data in all regions. In the HSE 2006 data, the highest prevalence of obesity was in the West Midlands (30%), and the lowest was in London and North West (21%). In the Nuffield Health dataset, the highest prevalence of obesity was in the North East and Yorkshire & The Humber (17%), and the lowest was in London (10%).

6.3.3.2 Waist circumference

6.3.3.2.1 Men

The prevalence of raised waist circumference in men was higher in the HSE 2006 data than in the Nuffield Health data across all regions. In the HSE 2006 data, the highest prevalence of raised waist circumference was in the South West (37%), and lowest was in London and Yorkshire & The Humber (30%). In Nuffield Health data, the highest prevalence of raised waist circumference was in the East Midlands (28%), and the lowest was in London (14%).

6.3.3.2.2 Women

Compared with data collected from HSE 2006, the prevalence of raised waist circumference in women in the Nuffield Health dataset was much lower in all regions. In the HSE 2006 data, the highest prevalence of overweight was in the South West (45%), and the lowest was in the North West (37%). In the Nuffield dataset, the highest prevalence of overweight was in the North West (30%), and the lowest was in London (20%).

6. 3.3.3 Total cholesterol

6.3.3.3.1 Men

The prevalence of raised total cholesterol in men was higher than 50% in both datasets. The prevalence of raised total cholesterol in men was lower in the HSE 2006 data than in the Nuffield Health data across all regions. In the HSE 2006 data, the highest prevalence of raised total cholesterol was in Yorkshire & The Humber (62%), and lowest prevalence was in London (52%). In the Nuffield Health dataset, the highest prevalence of raised total cholesterol in men was in the North East (72%), and the lowest was in London (60%).

6.3.3.3.2 Women

The prevalence of raised total cholesterol in women was higher than 50% in both datasets. The prevalence of raised total cholesterol in women was higher in the HSE 2006 data than in the Nuffield Health data across all regions apart from the East Midlands, where it was similar in both datasets (60% vs 61%). In the HSE 2006 data, the highest prevalence of raised total cholesterol was in the South West (66%), and lowest was in London (58%). The pattern was similar in the Nuffield Health data, with the highest prevalence also in South West (62%), and the lowest also in London (46%).

6.3.3.4 HDL cholesterol

6.3.3.4.1 Men

The prevalence of low HDL cholesterol in men was higher in the HSE 2006 data than in the Nuffield Health data in most of the regions. In the HSE 2006 data, the highest prevalence of low HDL cholesterol was in the West Midlands (14.1%), and lowest was in the South West (6.5%). In the Nuffield Health data, the highest prevalence was in the East Midlands (13.4%), and the lowest was in the North West (4.3%).

6.3.3.4.2 Women

The prevalence of low HDL cholesterol in women was generally very low in both datasets—under 3% of the population in all regions. The prevalence was slightly higher in the HSE 2006 data than in the Nuffield Health data for all of the regions apart from the East Midlands (where it was slightly higher in the Nuffield Health data [1.4% vs 0.6%]) and the West Midlands (where it was similar in the HSE and Nuffield datasets [1.8% vs 2.1%]). In the HSE 2006 data, the lowest prevalence of low HDL cholesterol was in the East Midlands (0.6%), and highest was in London (2.6%). In the Nuffield Health data, the lowest prevalence was in the North West (0.6%), and the highest was in the West Midlands (2.1%).

6.3.3.5 Hypertension

6.3.3.5.1 Men

The prevalence of hypertension in men was higher in the HSE 2006 data than in the Nuffield Health data in all the regions apart from the South East, where it was much higher in Nuffield Health data (31% vs 26%). In the HSE 2006 data, the highest prevalence of hypertension was in the North East (35%), and the lowest was in the South East (26%). In the Nuffield Health data, the highest prevalence was in the South East (31%), and the lowest was in London (16%).

6.3.3.4.2 Women

The prevalence of hypertension in women was much higher in the HSE 2006 data than in the Nuffield Health data in all regions. In the HSE 2006 data, the lowest prevalence of hypertension was in the East of England (23%), and highest was in Yorkshire & The Humber (30%). In Nuffield Health data, the lowest prevalence was in London (7%), and the highest was in the South West (17%).

No comparison was produced for WHR or LDL cholesterol because HSE 2006 did not include data for these risk factors.

6.4 DISCUSSION

Data for diet, tobacco use, and alcohol intake are available at the regional level for England, Scotland, and Wales (DoE 1970-4; Ministry of Agriculture, Fisheries and Food 1971-5). The evidence has shown that geographical variations have an effect on cardiovascular mortality related to diet or smoking (Armstrong *et al.* 1975; Chilvers and Adelstein 1981; Knox 1974). However, little is known about geographical variations in the distribution of cardiovascular risk factors such as obesity, hypertension, and hyperlipidaemia, in a population with access to private medical insurance. The results of the present study showed that participants from London were much healthier than those from other regions. Men from the Midlands, and especially those from the East Midlands, had relatively worse health conditions than those from

other regions, so did women from the Midlands. Interestingly, women from South England had similar health conditions to those from the Midlands.

Participants in the East Midlands and North West regions had a much higher risk of obesity than those from most other regions on the basis of three measures—BMI, waist circumference, and WHR. Participants in the South East had the highest risk, and those in York & The Humber the lowest risk, of being hypertensive. In terms of plasma cholesterol measures, the distribution among regions seemed variable—participants in the North East had the highest risk of elevated total cholesterol, and those in the North West had the lowest risk; both men and women in the Midlands were less likely to have low HDL cholesterol than those in other regions in England; and participants in North England were less likely to have high LDL cholesterol than those in other regions in England.

A few previous studies have detected a North–South effect, or a Scottish effect on prevalence of cardiovascular disease and associated risk factors (Lawlor *et al.* 2003; Shelton 2009). Similar effect has also been observed in France (Lang *et al.* 1999), Germany (Muller-Nordhorn *et al.* 2004) and Europe (Muller-Nordhorn *et al.* 2008). Shelton (2009) showed that there were significant geographic variations in cardiovascular risk factors between and within England and Scotland. At the national level, consumption of five or more portions of fruit and vegetables a day was significantly higher in England than Scotland in both men and women, smoking prevalence was significantly higher in Scotland than in England. However, this effect was not seen in the current study. This could be the study population in the present study, which is an affluent population in the UK. We could speculate that this effect might be able to be seen in the same population in other countries in Europe.

Some, but not all, of these findings were consistent with previous evidence. Lawlor and colleagues (2003), in the British Women’s Heart and Health Study of women aged 60–79 years from 23 towns in England, Scotland, and Wales, showed that the age-adjusted prevalence of obesity was highest in the Midlands & Wales, and lowest in South England (30·8% vs 24·9%). Women in North England had the lowest age-adjusted prevalence of hypertension, and those in the Midlands & Wales the highest (32·6% vs 34·3%). With respect to raised total cholesterol, women in North England and the Midlands & Wales had the lowest age-adjusted prevalence (16·2% and 16·4%, respectively), and the highest prevalence was in South England (17·9%).

The lowest prevalence of raised LDL cholesterol was found in North England (2.1%), and highest in the Midlands & Wales (4.2%). However, this study was in older women only, and only had four regions in about 7,000 participants. Shelton (2009) used two sets of public survey data, the 2003 Scottish Health Survey and the 2003 HSE, to detect regional difference in four risk factors—eating fruit and vegetables (5+ per day), smoking, obesity, and type 2 diabetes—in order to investigate health inequalities in Scotland and England. The results showed that men in London had the lowest prevalence of obesity (18%), with the highest prevalence in men from Yorkshire & The Humber (25%). The results were different for women, with those in the South East having the lowest prevalence of obesity (19%), and those in the West Midlands the highest (29%).

This geographical variation could be partly explained by large numbers of participants in the different regions in the present study. Another possible explanation could be geographical variations in health service access or quality, or in the use of aspirin and statins, which could be a proxy indicator of health service utilisation (Ebrahim *et al.* 1998; Lawlor *et al.* 2003; Perry *et al.* 2000). In some areas, deprivation could be a good marker on cardiovascular risks. This could vary by region and thus alter the strength of the relation between deprivation and cardiovascular risks (Eames *et al.* 1993). A few studies have reported that cholesterol decreased in lower socioeconomic groups due to the reduction of intake of saturated fats, lower alcohol consumption, and consumption of more fruit, vegetables, and whole grains (Briefel and Johnson 2004; Kanjilal *et al.* 2006; Marmot *et al.* 1991; McFadden *et al.* 2009; Popkin *et al.* 1996).

Individual regions are a complex mixture of smaller areas, which differ considerably in the prevalence of cardiovascular risk factors, and will certainly differ substantially with respect to smoking, alcohol consumption, and dietary patterns. In general, the cardiovascular risk factor profile of a region tends to be worse in the North of England than in the South of England, due to climatic factors such as rainfall and temperature (Roberts and Lloyd 1972; West *et al.* 1973), water hardness (Morris *et al.* 1961), and social deprivation (Carstairs and Morris 1989; Eames *et al.* 1993). This is a pattern that part of the current study's findings is in agreement with—both men and women in South England were less likely to be obese than those in other regions.

Several environmental factors—water hardness, rainfall, and temperature—and certain social factors substantially explain the geographical variations in cardiovascular mortality in the UK. The broader definition of social factors covers a wide range of behavioural variables and phenomena associated with living standards and conditions. Climatic factors can even have an effect on lifestyle on the basis of physical activity in leisure times, smoking and drinking habits, and dietary preferences. Evidence has shown the ways in which social factors might be reflected in behaviours such as smoking and drinking, and in physiological measurements such as overweight, blood pressure, and blood lipids (Shaper *et al.* 1981).

More affluent areas might be greater beneficiaries of health promotion than less favoured areas. The traditional focus on individual risk-factor modification has broadened to take in areas such as the social environment with, for example, the “Healthy Cities” project (Ashton 1992). Social-directed policies such as improvement of child benefits and pensions, and provision of employment opportunities and good-quality housing could also have a major effect (Lancet 1990).

6.4.1 Comparison of prevalence of modifiable cardiovascular risk factors between the Nuffield dataset and the Health Survey for England 2006

Overall, the prevalence of various modifiable cardiovascular risk factors was higher in HSE 2006 data than in the Nuffield Health data for both men and women across all regions in England. In men, the prevalence of overweight, raised waist circumference, and raised total cholesterol was higher in the Nuffield Health data than in HSE data. Men in London were generally healthier than those in other regions in England. Differences in prevalence of several risk factors were wide between regions, such as raised waist circumference (up to two times), low HDL cholesterol (over three times), and hypertension (about two times). In women, the prevalence of obesity, raised waist circumference, and hypertension was much lower in the Nuffield Health data than in the HSE 2006 data. Only the difference in the prevalence of hypertension was wide between regions (more than two times). The distribution of cardiovascular risk factors in the affluent population did not mirror the distribution of cardiovascular risk factors in the general population on regional variation. These findings could be because the participants who attended Nuffield Health were much wealthier than those in the HSE 2006 data. However, HSE 2006 was not designed to provide local area data—the

sample sizes (16,000 adults and 7,300 children in 2006) were too small to provide reliable estimates below the regional level.

This study provided a unique opportunity to show how geographical region affects modifiable cardiovascular risk factors in a large UK population from private medical screenings. These risk factors could have led to subsequent risk of cardiovascular disease. This is the only study reported to date that includes such a large number of cardiovascular risk factors in a primary care setting. However, the fact that the population was made up exclusively of participants registered in private medical insurance might be considered a limitation of this study. The participants all had access to private health care either through their employer or from self-funding, meaning that the sample reflected the more affluent sectors of the population. This might have an effect on the geographical variations, but not for the purpose of this research. Shelton (2009) found that significant geographical variation remained once individual socioeconomic status was taken into consideration, but the relationship was complex and further research is needed. Another limitation of this study is that the dataset does not include a history of medication use. Use of lipid-lowering drugs, primarily statin therapy, is recommended for patients with clinical evidence of cardiovascular disease. However, data from a private medical insurance company is limited—participants still see their general practitioners (GPs) to prescribe medication. Therefore, it was impossible to identify whether a participant's blood pressure and cholesterol level was drug-controlled. Other limitations include the complexity and heterogeneity of the data, which might introduce some bias into the analyses.

Geographical variations in the prevalence of modifiable cardiovascular risk factors have been reported both between and within countries (Crombie *et al.* 1990; Eames *et al.* 1993; Morris *et al.* 2001; Nebrand *et al.* 1991; WHO MONICA Project Principle Investigators 1988). Lawlor and colleagues (2003) measured the geographical variation in prevalence of cardiovascular disease and associated risk factors, as well as their control in a national sample of 7,173 women aged 60–79 from 23 towns in England, Scotland, and Wales. Their findings for the prevalence of major risk factors by geographical region are partly in agreement with results of the present study. The variation in cardiovascular risk factors can be explained by differences in dietary consumption of fats, sugars, and green, leafy vegetables and the prevalence of obesity. The Seven Countries Study was the first to make systematic comparisons of cardiovascular disease

rates and characteristics of risk in different cultures (Keys 1980; Kromhout *et al.* 1989; Toshima *et al.* 1994). Keys and collaborators (1980) hypothesised that differences in population-level cardiovascular disease and individual-level risks were related to lifestyle risks including diet. Formal cross-sectional surveys were conducted starting in 1958 among men aged 40–59 years in different cultures in Yugoslavia, Italy, Greece, Holland, Finland, Japan, and the USA. The Seven Countries Study was the first to carry out both cross-sectional and summarise of a 35-year collaborative experience of epidemiology research in populations contrasting in cardiovascular disease rate, lifestyle, and diet (Toshima *et al.* 1994). This study also demonstrated that the major cardiovascular risk factors were common in importance and that the penetrance of risk factors differed between contrasting populations and between populations and individuals. The 2003 WHO MONICA study evaluated cardiovascular events and trends in mortality and risk factors in 21 countries across Europe, North America, Asia, and Australasia. The objective of this study was to measure trends in cardiovascular mortality, and coronary heart disease (CHD) and stroke morbidity, and to assess to extent to which these trends were related to changes in risk factors, daily living habits, health care, or major socioeconomic features. A large difference in cardiovascular disease event rates and mortality was observed in different countries, with high rates in Finland, Scotland, Iceland, and Denmark and low rates in Italy, Spain, and China. The cardiovascular disease mortality rates correlated with lifestyle and associated risk factors.

Differences in cardiovascular mortality, especially a higher mortality have been noted in southeastern states, as compared with other states in the USA. This is related to a higher prevalence of hypertension and other lifestyle risk factors in these regions (Asplund 2004). In the Ni-Hon-San study, Abraham Kagan and colleagues (1973) examined physical characteristics, dietary intake, and biochemical markers among three groups of Japanese men living in Japan, Hawaii, and California. Consumption of dietary saturated fat in the three populations was reported to be 7%, 12%, and 14%, respectively. Evidence for regional difference in cardiovascular mortality that is related to major cardiovascular risk factors exists in many other countries of the world including Sweden, France, and Italy (Artauld-Wild *et al.* 1993; Criqui and Ringel 1994; Nerbrand *et al.* 1992). In Europe the national differences can be explained on the basis of high-fat diets in the countries of the north and a high intake of green, leafy vegetables, monounsaturated fats, and wine in the southern countries (WHO and WHO MONICA Project Investigators 2003). Artauld-Wild *et al.* (1993) examined coronary mortality

in 40 countries in Europe and correlated it with cholesterol, saturated fats, and 40 dietary variables. A cholesterol–saturated fat index was significantly and positively related to cardiovascular mortality in these 40 countries at various levels of economic development. Intake of milk and other dairy products was associated with increased cardiovascular mortality, whereas intake of vegetables and other plant-based foods was associated with reduced cardiovascular mortality.

Participants from London were much healthier than those from other English regions. According to the Office for National Statistics (2011), London's population is young compared with the rest of the country, and young people tend to be healthier than older people. The average age of a Londoner is 37 years, compared with 40 years for the UK as a whole. This is because young people tend to work and live in world metropolitan cities such as London. However, the health inequality gap is increasing (Marmot 2010). People in the top 10% of households earn around five and half times more than those in the bottom 10%. The population of London is now over 8.2 million, and is expected to continue to grow to more than 9.5 million over the next 20 years. London therefore faces a unique set of complex challenges in protecting and improving the cardiovascular health of its inhabitants.

Remaining variation could be explained by geographical variation in access to or quality of health services, or both. The geographical variations in CHD mortality rates suggest that dramatic improvements in CHD mortality in the UK are still attainable. For example, if every local authority in the UK had the same CHD mortality rate as Kensington and Chelsea, there would be approximately 32,500 fewer deaths every year in England, almost 5,500 fewer deaths in Scotland, 3,000 fewer deaths in Wales, and 1,300 fewer deaths in Northern Ireland; i.e. a total of over 42,000 fewer deaths in the United Kingdom, including 15,000 fewer premature deaths before age 75 years (Scarborough *et al.* 2008). There is also some geographical variation in the prevalence of cardiovascular disease. The HSE 2003 suggested that 20% of men in Yorkshire and the Humber and 19% in the West Midlands report ever having had some form of diagnosed cardiovascular disease, compared with 15% of men in the South West and 16% in London and the East of England. Furthermore, the prevalence of CHD in men is nearly twice as high in Yorkshire and the Humber (12%) as in the South West (7%) and East of England (7%). Correspondingly, prevalence of cardiovascular disease for women ranges from 14% in London to 20% in the West Midlands. CHD varies even more dramatically; only 4% of women

in the South West and East of England report a doctor's diagnosis of CHD, compared with 10% of women in the North East (Department of Health 2004).

6.5 CONCLUSIONS

Geographical region has an effect on modifiable cardiovascular risk factors. Several risk factors have different effects on men and women, so it is essential that studies present results by sex. Although geographical variations in death rates from coronary heart disease have been observed in the UK for many years, few studies here looked at the effect of geographical variations in cardiovascular risk factors, and most are from different phases of the British Regional Heart Study. These studies investigated the effect of geographical region on cardiovascular mortality, but even less available data in cardiovascular risk factor profile.

Several environmental factors—water hardness, rainfall, and temperature—and certain social factors might substantially explain the geographical variations in cardiovascular mortality in the UK, but further research into the underlying reasons for the observed differences in cardiovascular risk factors in the UK both between and within regions is needed. As seen in the *Health and Lifestyles in the North West* (2007)—populations in more affluent areas could benefit from health promotion (diet, behavior change, lifestyle and physical activity mainly) and campaigns than those in less affluent areas. Therefore, deprivation (include the access to health service or quality) could be a good marker for cardiovascular risks in geographical variations. Ethnic groups such as south Asians living in the UK—Indians, Bangladeshis, Pakistanis, and Sri Lankans—have much higher premature death rate from cardiovascular disease compared with the white population. Strategies in preventive and treatment targeted white population might not be applicable to ethnic minorities. Therefore, strategies targeted on ethnic groups should be specifically developed, validated, and assessed to consider both cultural acceptability and underlying susceptibility.

Multilevel analyses combining individual patient data with aggregate data could be a feasible approach to identify the risk factors that contribute the most to regional variations. Such research would allow prevention strategies that target specific risk factors. In addition, the monitoring of cardiovascular disease and risk factors in the UK could become more

manageable. These actions will require the involvement of both primary care health professionals (prevention and detection) and secondary health care settings (appropriate investigation and management and adequate control).

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CHAPTER 7:

COMPARISONS BETWEEN PREVALENCE OF MODIFIABLE CARDIOVASCULAR RISK FACTORS IN PEOPLE ATTENDING PRIVATE MEDICAL SCREENING AND NATIONAL HEALTH SERVICES FROM SOUTH ENGLAND IN DIFFERENT AGE GROUPS

ABSTRACT

Aim: In chapter 4, the prevalence rate of various modifiable cardiovascular risk factors for clients who attended private health centres across the UK by age and sex was examined. This chapter aimed to compare the prevalence of various cardiovascular risk factors between the people who attended Nuffield Health and individuals who attended local general practitioner clinics in south England.

Methods: Data are provided by Hampshire Health Record (HHR), NHS Hampshire. Seven risk factors were analysed: body-mass index (BMI), waist size, systolic and diastolic blood pressure, and total, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol. Age was divided into six groups: 18–24, 25–34, 35–44, 45–54, 55–64, and 65–75 years. Prevalence was calculated for each modifiable risk factor proportionately. Comparison outcomes were analysed by *chi-square* test to see the difference between people who attended Nuffield Health and those who attended general practice in south England. All baseline data were analysed at a 0.05 α level to determine statistical significance.

Results: In the overall population, participants aged 65–75 years had the highest prevalence of overweight (39.8%); participants aged 55–64 and 65–75 years both had the highest prevalence obesity (23.5%); participants aged 45–54 years had the highest prevalence of morbid obesity (3.3%). The general pattern of high waist circumference in the overall population, men and women, is directly proportional to age, with the exception of men aged 65–75 years. Men aged 55–64 years had the highest prevalence of very high waist circumference, at 50.5%. Women who were aged 65–75 years had the highest prevalence of very high waist circumference of 65.7%. In overall population, participants aged 65–75 years (group 6) had the highest prevalence of high systolic and diastolic blood pressure. Men were more likely to have a higher

prevalence of higher systolic blood pressure and diastolic blood pressure than were women. 48.6% of men and 33.7% of women, respectively, had high systolic blood pressure; and 12.3% of men and 7.1% of women, respectively, had high diastolic blood pressure. In the overall population, the highest prevalence of elevated total cholesterol and LDL were found in group 5 (aged 55–64 years), but the highest prevalence of low HDL was found in group 3 (aged 35–44 years). When data were compared between Hampshire Health Record and Nuffield Health, significant differences were found between individual cardiovascular risk factors, and within different age groups, mostly because of sample size—the dataset from the NHS trust is at least ten times larger than the Nuffield dataset (with a maximum that could be up to 100 times).

Discussion: Overall, about one in two people were overweight or obese in HHR. Participants tend to have higher systolic blood pressure, but lower diastolic blood pressure. About 60% and 45% of participants have elevated total cholesterol and LDL, respectively, and 16% participants have lower HDL. It was hypothesised that the population from the NHS trust dataset has a lower BMI than the one from the Nuffield Health dataset. However, women had a lower BMI in the Nuffield Health dataset. Also, although many risk factors contribute to cardiovascular diseases in both men and women, the cardiovascular risk factors for women are the same as those in men, such as cigarette smoking, elevated serum cholesterol, elevated blood pressure and a sedentary lifestyle. Difference in cardiovascular risk factors is not only because of the gender difference. Many other aspects could have an effect on the contribution to cardiovascular disease. These include: the effect of adult lifestyle, potential genetic differences, developmental conditions throughout the life course, per se and operating through social determinants, rapid urbanisation, androgen level, low birthweight, limited living conditions in childhood, low-carbohydrate high-protein diet, collectivist society, and psychological stress.

Conclusion: Based upon data from Nuffield Health and Hampshire Health Record, participants aged 55–75 years who signed up to private medical insurance and in south England need to pay more attention to their cardiovascular health. They may need to care more about their lifestyle and diet, and exercise more. Structured exercise and school sport can make an important contribution to an individual's physical activity. A physically active lifestyle can reduce the risk of many chronic conditions including coronary heart disease, stroke, obesity, and mental health problems. There is evidence that action at multiple levels is effective in increasing physical activity, from primary care professionals encouraging individuals to lead

active lives, to local authorities investing in community-level activity programmes and employers promoting active workplaces.

7.1 INTRODUCTION

Cardiovascular disease is the leading cause of premature death and a major cause of disability in the UK (BHF 2007). In 2010, cardiovascular disease was responsible for around one in three premature deaths (under age 75 years) in men and one in five premature deaths in women. Coronary heart disease and stroke are the main causes of cardiovascular disease mortality. The World Health Organization (WHO 2009) toolkit estimates that the top ten risk factors for early death and disability in the UK are, in order of impact: tobacco use, harmful alcohol consumption, high blood pressure, high blood cholesterol, overweight and obesity, physical inactivity, illicit drug use, low fruit and vegetable intake, occupational risks, and poor sexual health. Approximately 25% of people aged 16 years and over report one lifestyle risk factor, 33% two risk factors, 23% three risk factors, and 12% four or more risk factors. Only 7% of adults have no risk factors (HSE 2010). This chapter looks at various cardiovascular risk factors in the datasets from Nuffield Health and Hampshire Health Record, and compares the prevalence of these risk factors by different age groups and sex, which are relevant to two databases analysed in the study.

These results show that the majority of adults in England have multiple lifestyle risks to their health. Among males, the percentage with four or more risk factors increases from 3.5% of 16–24 year olds, to 21.4% of those aged 55–64 years, before declining to 11% of those aged 75 years and over. Among females, the percentage with four or more risks rises from 5.5% of 16–24 year olds, to 16.2% of those aged 65–74 years, before falling to 12.7% of the group aged 75 years and over. For both sexes, the increase between the first two age groups is mainly due to the rise with age in the prevalence of raised cholesterol, hypertension, obesity, and diabetes. There is evidence that the percentage of adults with multiple risk factors is decreasing. For example, 47.9% of males had three or more risk factors in 2003 compared with 37.5% in 2010. Among females, the figure fell from 39.1% to 33.7% over the same period. These improvements are mainly due to the reduced prevalence of raised cholesterol, hypertension, and smoking, although over the same period, there has been a less positive decline in healthy eating levels, an increase in binge drinking, and increases in the prevalence of obesity and diabetes. Understanding the way these factors interact is central to increasing the effectiveness of interventions to improve health and wellbeing, and to reducing inequalities.

Hypertension is the most important modifiable risk factor for cardiovascular disease. The percentage of the population with high blood pressure increases progressively with age. In 2008–10, 4.1% of 14–24 year olds had high blood pressure, compared with 25.9% of 45–54 year olds and 72.8% of people aged 75 years and over. There is evidence that the prevalence of high blood pressure is increasing in older age groups, although the percentage whose hypertension is not controlled by medication is decreasing. The estimated prevalence of high blood pressure varies across England. More than 35% of adults in parts of south west and south east England have high blood pressure, compared with less than 25% in several London boroughs and elsewhere. A controlled trial reporting on the effects of screening, the South-East London Screening Study (SELSS), was conducted in 1967 and involved 7229 participants aged between 40 and 64 years from two local group general practices. No significant differences were found between the screened and the non-screened groups in any of the outcome measures such as raised diastolic blood pressure (≥ 105 mm Hg) (The South-East London Screening Study Group 1977).

There is evidence that cholesterol levels have been falling over time, largely as a result of an increase in the prescribing of statins and other lipid-lowering drugs; between 1994 and 2006, the percentage of men with raised cholesterol fell from 74% to 57% and among women from 77% to 61%. The prevalence of raised cholesterol increased from 31% of females and 20% of males aged 16–24 years, peaked at 84% of women aged 55–64 years and 74% of men aged 45–54 years, and then fell again for both sexes in the oldest age groups. The percentage of adults with raised cholesterol is broadly comparable across English regions, although the percentage of women in the south west with this risk factor is higher than the English average at 66%, as is the percentage of males in Yorkshire and the Humber at 62%.

Patterns of obesity differ substantially by age. Among adults, the prevalence of obesity rises from 11.2% of those aged 16–24 years, peaks at 32.4% among those aged 55–64 years, before falling to 25.2% of people aged 75 years and over. There are also differences in prevalence between the sexes, with females having higher levels of obesity in the 16–24 years and 65 years and over age groups, and men having higher levels between the ages of 45 and 64 years. Common to both sexes and all age groups has been a progressive increase in levels of obesity. Geographic variation exists. The modelled distribution of obesity differs, with the highest

estimated percentages found in parts of the north west, Yorkshire and the Humber, west Midlands, and the south east.

There is clear evidence that dietary control and physical activity are effective in reducing obesity and overweight at an individual level, although creating environments that promote and enable healthy eating and active lives requires action across industry, Local Government, and the NHS.

The data sources available to quantify the prevalence of the different behavioural risks provide a strong basis for understanding the varying health burden that these factors place on different groups in the population and across the life course. For example, alongside the age, sex, socioeconomic, and ethnic group differences in smoking rates, there are similar variations in alcohol consumption patterns and the distribution of alcohol-related harm.

South England is a more affluent region in the UK compared with other regions. Nuffield Health is a private medical insurance company, so people who attended Nuffield Health were more likely to be from a higher socioeconomic class. It is therefore reasonable to compare the population who attended Nuffield Health with those located in south England in terms of different age groups (and socioeconomic status in the following chapter), but not regional variation. This chapter compares the prevalence of various cardiovascular risk factors between the people who attended Nuffield Health and individuals who attended local general practitioner (GP) clinics in south England, and to identify the similarities and differences of two datasets in relation to the cardiovascular risk factors.

7.2 DESIGN AND METHODS

7.2.1 Study setting and data collection

Data are provided by Hampshire Health Record, NHS Hampshire. The Hampshire Health Record is a joint project supported by Basingstoke and North Hampshire Foundation Trust, Hampshire Primary Care Trust, Portsmouth City Teaching Primary Care Trust, Portsmouth Hospitals NHS Trust, Southampton City Primary Care Trust, Southampton University

Hospitals NHS Trust, and Winchester and Eastleigh Hospital NHS Trust. HHR provides a detailed record of care which contains most of the information held in the GP's record. It is stored by using a coding scheme (called READ Codes), which enables the data to be easily processed and displayed, whilst ensuring the quality and accuracy of the data is of a suitable level. Using this coding system means that only clinical data is shared and any comments GP may record for their own use are not shared. The amount of information will vary between patients, but will normally include information about allergies, medication, diagnosis, tests, and treatments.

7.2.2 Cardiovascular risk factors

Several established cardiovascular risk factors represent the risk profile of the participants: (1) anthropometric characteristics; (2) blood pressure; and (3) plasma serum. We examined BMI and waist circumference. BMI is defined as: (1) underweight (below 18.5 kg/m²); (2) normal (between 18.5 and 25 kg/m²); (3) overweight (over 25 but less than 30 kg/m²); (4) obese (over 30 but less than 40 kg/m²); or (5) morbidly obese (over 40 kg/m²) (HSE 2008). Waist circumference was measured at the anatomical waist. For men, low waist circumference is defined as less than 94 cm, high as 94–102 cm, and very high as greater than 102 cm; for women, low waist circumference is less than 80 cm, high is 80–88 cm, and very high is greater than 88 cm (NICE 2006a). Blood pressure included systolic blood pressure and diastolic blood pressure. Hypertension was classified as greater than 90 mm Hg (diastolic) and greater than 140 mm Hg (systolic) (NICE 2006b). Plasma serum includes total, HDL, and LDL cholesterol. Total cholesterol was classified as raised if higher than 6 mmol/L. HDL was classified as low if less than 1.0 mmol/L; LDL was defined as raised if greater than 3.36 mmol/L (Contois *et al.* 1996). Age was divided into six groups: 18–24, 25–34, 35–44, 45–54, 55–64, and 65–75 years, which are similar to the Health Survey for England.

7.2.3 Statistical analysis

Data from this study were analysed with SPSS version 17.0 (SPSS Inc, Chicago, IL, USA). The dependent measures were modifiable risk factors—eg, BMI, waist circumference, blood pressure, plasma cholesterol, etc. Prevalence was calculated for each modifiable risk factor proportionately. Comparison outcomes were analysed by *chi-square* test to see the difference between people who attended Nuffield Health and those who attended general practices in south England. All baseline data were analysed at a 0.05 α level to determine statistical significance.

7.3 RESULTS

Table 7.1 shows the prevalence of modifiable cardiovascular risk factors in the overall population. Tables 7.2 and 7.3 show prevalence of modifiable cardiovascular risk factors in different age groups in men and women, respectively. Figures mentioned in the 7.3.1 – 7.3.3 are highlighted in blue in these tables.

Table 7.1: Prevalence of modifiable cardiovascular risk factors in different age groups

	Group 1, age 18–24 years	Group 2, age 25–34 years	Group 3, age 35–44 years	Group 4, age 45–54 years	Group 5, age 55–64 years	Group 6, age 65– 75 years	Total
Body-mass index (n)	46 856	116 538	119 189	121 573	101 216	90 476	595 848
Underweight (n)	7072	7417	3323	1974	1489	1412	22 687
%	15.1%	6.4%	2.8%	1.6%	1.5%	1.6%	3.8%
Normal (n)	28 830	68 650	57 866	48 923	35 185	29 431	268 885
%	61.5%	58.9%	48.5%	40.2%	34.8%	32.5%	45.1%
Overweight (n)	6977	25 586	35 820	41 571	37 441	35 988	183 383
%	14.9%	22.0%	30.1%	34.2%	37.0%	39.8%	30.8%
Obese (n)	3397	12 744	19 009	25 152	23 819	21 229	105 350
%	7.2%	10.9%	15.9%	20.7%	23.5%	23.5%	17.7%
Morbidly obese (n)	580	2141	3171	3953	3282	2416	15 543
%	1.2%	1.8%	2.7%	3.3%	3.2%	2.7%	2.6%
Waist circumference (n)	730	2612	3054	4453	5857	7766	24 472
High (n)	80	347	561	925	1278	1780	4971
%	11.0%	13.3%	18.4%	20.1%	21.8%	22.9%	20.3%
Very high (n)	149	611	1097	2204	3271	4424	11 756
%	20.4%	23.4%	35.9%	49.5%	55.8%	57.0%	48.0%
Systolic blood pressure (n)	43 713	91 018	117 463	139 715	190 436	210 009	792 354
n	2573	9887	24 325	50 905	98 254	127 914	313 858
%	5.9%	10.9%	20.7%	36.4%	51.6%	60.9%	39.6%
Diastolic blood pressure (n)	50 456	134 567	146 637	152 378	134 234	118 598	736 841
n	612	4637	10 943	21 207	19 634	17 767	73 809
%	1.2 %	3.4%	7.5%	13.9%	14.6%	15.0%	10.1%
Total cholesterol (n)	2857	11 642	36 125	101 601	176 242	279 780	608 247
n	718	4213	18 715	61 991	112 036	163 714	361 387
%	25.1%	36.2%	51.8%	61.0%	63.6%	58.5%	59.4%
High-density lipoprotein (n)	2180	8476	26 548	72 559	123 954	187 582	421 299
n	403	1757	5933	14 106	19 954	25 958	68 111
%	18.5%	20.7%	22.3%	19.4%	16.1%	13.8%	16.2%
Low-density lipoprotein (n)	398	1265	4305	12 501	22 342	35 324	76 135
n	70	311	1755	5778	10 728	15 319	33 961
%	17.6%	24.6%	40.8%	46.2%	48.0%	43.4%	44.6%

Table 7.2: Prevalence of modifiable cardiovascular risk factors in different age groups in men

	Group 1, age 18–24 years	Group 2, age 25–34 years	Group 3, age 35–44 years	Group 4, age 45–54 years	Group 5, age 55–64 years	Group 6, age 65– 75 years	Total
Body-mass index (n)	18 991	47 726	54 847	57 730	49 102	44 189	272 585
Underweight (n)	3508	2897	1169	568	502	490	9134
%	18.5%	6.1%	2.1%	1.0%	1.0%	1.1%	3.4%
Normal (n)	11 871	28 337	24 876	19 451	14 155	12 506	111 196
%	62.5%	59.4%	45.4%	33.7%	28.8%	28.3%	40.8%
Overweight (n)	2470	11 578	19 640	24 066	21 326	20 178	99 258
%	13.0%	24.3%	35.8%	41.7%	43.4%	45.7%	36.4%
Obese (n)	973	4370	8316	12 367	12 054	10 247	48 327
%	5.1%	9.2%	15.2%	21.4%	24.5%	23.2%	17.7%
Morbidly obese (n)	169	544	846	1278	1065	768	4670
%	0.9%	1.2%	1.5%	2.2%	2.2%	1.7%	1.7%
Waist circumference (n)	297	1139	1539	2390	3296	4229	12 890
High (n)	24	129	301	578	820	1139	2991
%	8.1%	11.3%	19.6%	24.2%	24.9%	26.9%	23.2%
Very high (n)	18	142	386	978	1665	2101	5290
%	6.1%	12.5%	25.1%	41.0%	50.5%	49.7%	41.0%
Systolic blood pressure (n)	7686	19 687	36 815	60 364	89 040	100 042	313 634
n	974	4486	12 166	26 214	48 488	60 114	152 442
%	12.7%	22.8%	33.0%	43.4%	54.5%	60.1%	48.6%
Diastolic blood pressure (n)	16 451	51 146	64 004	72 355	61 767	57 480	323 203
n	236	2545	6821	11 975	10 943	7353	39 873
%	1.4%	5.0%	10.7%	16.6%	17.7%	12.8%	12.3%
Total cholesterol (n)	1379	5472	19 124	57 379	99 395	151 962	334 711
n	296	1963	10 737	36 346	58 632	77 515	185 489
%	21.5%	35.9%	56.1%	63.3%	59.0%	51.0%	55.4%
High-density lipoprotein (n)	1060	3932	14 020	40 484	68 789	99 871	228 156
n	255	1082	4180	10 484	15 909	20 556	52 466
%	24.1%	27.5%	29.8%	25.9%	23.1%	20.6%	23.0%
Low-density lipoprotein (n)	210	636	2348	7172	12 675	19 172	42 213
n	35	159	1065	3641	5833	7243	17 976
%	16.7%	25.0%	45.4%	50.8%	46.0%	37.8%	42.6%

Table 7.3: Prevalence of modifiable cardiovascular risk factors in different age groups in women

	Group 1, age 18–24 years	Group 2, age 25–34 years	Group 3, age 35–44 years	Group 4, age 45–54 years	Group 5, age 55–64 years	Group 6, age 65– 75 years	Total
Body-mass index (n)	27 865	68 812	64 342	63 843	52 114	46 287	323 263
Underweight (n)	3564	4520	2154	1406	987	922	13 553
%	12.8%	6.6%	3.3%	2.2%	1.9%	2.0%	4.2%
Normal (n)	16 959	40 313	32 990	29 472	21 030	16 925	157 689
%	60.9%	58.6%	51.3%	46.2%	40.4%	36.6%	48.8%
Overweight (n)	4507	14 008	16 180	17 505	16 115	15 810	84 125
%	16.2%	20.4%	25.1%	27.4%	30.9%	34.2%	26.0%
Obese (n)	2424	8374	10 693	12 785	11 765	10 982	57 023
%	8.7%	12.2%	16.6%	20.0%	22.6%	23.7%	17.6%
Morbidly obese (n)	411	1597	2325	2675	2217	1648	10 873
%	1.5%	2.3%	3.6%	4.2%	4.3%	3.6%	3.4%
Waist circumference (n)	433	1473	1515	2063	2561	3537	11 582
High (n)	56	218	260	347	458	641	1980
%	12.9%	14.8%	17.2%	16.8%	17.9%	18.1%	17.1%
Very high (n)	131	469	711	1226	1606	2323	6466
%	30.3%	31.8%	46.9%	59.4%	62.7%	65.7%	55.8%
Systolic blood pressure (n)	36 027	71 331	80648	79 351	101 396	109 967	478 720
n	1599	5401	12 159	24 691	49 766	67 800	161 416
%	4.4%	7.6%	15.1%	31.1%	49.1%	61.7%	33.7%
Diastolic blood pressure (n)	33 973	79 100	74 634	76 816	63 081	59 206	386 810
n	361	1887	3991	7229	7695	6412	27 575
%	1.2%	2.4%	5.3%	9.4%	12.2%	10.8%	7.1%
Total cholesterol (n)	1478	6170	17 001	44 222	76 847	127 818	273 536
n	422	2250	7978	25 645	53 404	86 199	175 898
%	28.6%	36.5%	46.9%	58.0%	69.5%	67.4%	64.3%
High-density lipoprotein (n)	1120	4544	12 528	32 075	55 165	87 711	193 143
n	148	675	1753	3622	4045	5402	15 645
%	13.2%	14.9%	14.0%	11.3%	7.3%	6.2%	8.1%
Low-density lipoprotein (n)	188	629	1957	5329	9667	16 152	33 922
n	35	152	690	2137	4895	8076	15 985
%	18.6%	24.2%	35.3%	40.1%	50.6%	50.0%	47.1%

7.3.1 Adiposity

7.3.1.1 Body-mass index

In the overall population (table 7.1), participants aged between 65 and 75 years (group 6) had the highest prevalence of being overweight (39.8%). Both group 5 and 6 (ages 55-64 and 65-75 years, respectively) had the highest prevalence of obesity (23.5%). The highest prevalence of morbid obesity was found in group 4 (ages 45-54 years) and equaled 3.3%. For men, the highest prevalence of being overweight occurred in group 6 (ages 65-75 years) and equaled 45.7%. Group 5 (ages 55-64 years) was the one with the highest prevalence of obesity, which was 24.5%. The highest prevalence of morbid obesity equaled 2.2% and was found in both group 4 (ages 45-54 years) and group 5 (ages 55-64 years). For women, group 6 (ages 65-75 years) was the one with the highest prevalence of overweight and obesity (34.2% and 23.7%, respectively). Group 4 (ages 45-54 years) was the one with the highest prevalence of morbid obesity, which equaled 4.2%.

In the overall population (table 7.1), participants aged between 45 and 54 years had the highest prevalence of being overweight, obese, and morbidly obese (22.7%, 23.9%, and 25.4%, respectively). For men (table 7.2), those aged 45–54 years had the highest prevalence of being overweight, obese, and morbidly obese compared with other age groups (24.2%, 25.6%, and 27.4%, respectively). For women (table 7.3), those aged 65–75 years had the highest prevalence of being overweight and obese (34.2% and 23.7%, respectively). Women aged 45–54 years had the highest prevalence of morbid obesity (24.6%).

In the overall population (table 7.1), the prevalence of overweight gradually increased with age up to 75 years; the prevalence of obesity increased with age up to 64 years and then stayed at the same level and the prevalence of morbid obesity increased with age up to 54 years and then started to decrease afterwards. In terms of prevalence of overweight, men shared the same pattern as the overall population (table 7.2). The prevalence of obesity in men increased with age up to 64 years and started to decrease afterwards. 54 years was the age up to which the prevalence of morbid obesity in men increased to stay at the same level up to age of 64 years and then decrease afterwards. For women (table 7.3), the pattern shows that the prevalence of becoming overweight or obese is proportional to increase in age and thus rises from age 18

years all the way through to 75 years of age. Prevalence of morbid obesity in women increases up to age of 54 years and decreases afterwards to slightly increase closer to age of 75 years. The lowest prevalence is in 18–24 year olds in the overall population (table 7.1), men (table 7.2), and women (table 7.3).

7.3.1.2 Waist circumference

The general pattern of high waist circumference in the overall population (table 7.1), men (table 7.2), and women (table 7.3) is directly proportional to age. Men had a higher prevalence of high waist circumference than women (23.2% to 17.1%). Women had a higher prevalence of very high waist circumference than men (55.8% to 41.0%).

Men (table 7.2) aged 65–75 years had the highest prevalence of high waist circumference, at 26.9%. The second highest prevalence was found in men aged 55–64 years, in whom the rate was 24.9%. The lowest prevalence of high waist circumference was found in men aged 18–24 years and equaled 8.1%. For women (table 7.3), those aged 65–75 years had the highest prevalence of high waist circumference, at 18.1%. The second highest prevalence was in women aged 55–64 years, in whom the rate was 17.9%. The lowest prevalence of high waist circumference in women was also found in those aged 18–24 years and equaled 12.9%.

The highest prevalence of very high waist circumference was 50.5% in men (table 7.2) and 65.7% in women (table 7.3), at age 55–64 years for men and 65–75 years for women. The lowest prevalence of very high waist circumference was 6.1% in men and 30.3% in women, both at age 18–24 years.

7.3.2 Blood pressure

7.3.2.1 Systolic blood pressure

In the overall population (table 7.1), participants aged 65–75 years (group 6) had the highest prevalence of high systolic blood pressure; those aged 55–64 (group 5) had the second highest

prevalence of high systolic blood pressure. Participants aged 18–24 (group 1) had the lowest prevalence of high systolic blood pressure.

Men were more likely to have a higher prevalence of higher systolic blood pressure than were women. The figures were 48·6% in men (table 7.2) and 33·7% in women (table 7.3), respectively.

For men (table 7.2) and women (table 7.3), the highest prevalence of higher systolic blood pressure was both found in group 6; the figures were 60·1% and 61·7%, respectively. The second highest prevalence of higher systolic blood pressure was also both found in group 5; the figures were 54·5% and 49·1%, respectively. The lowest prevalence was found in group 1 for both men and women; the figures were 12·7% and 4·4%, respectively.

7.3.2.2 Diastolic blood pressure

In the overall population (table 7.1), participants aged 65–75 years (group 6) had the highest prevalence of high diastolic blood pressure. Those aged 55–64 years (group 5) had the second highest prevalence of high diastolic blood pressure. Participants aged 18–24 years (group 1) had the lowest prevalence of high diastolic blood pressure.

The prevalence of high diastolic blood pressure shared the same pattern as that of high systolic blood pressure in men (table 7.2) and women (table 7.3). The figures were 12·3% in men and 7·1% in women. The highest prevalences of higher diastolic blood pressure were found in group 5 (age 55–64 years) for both men and women and equaled 17·7% and 12·2%, respectively. The second highest prevalence of higher diastolic blood pressure was found in men in group 4 (16·6%) and in women in group 6 (10·8%). For men and women, the lowest prevalence of higher diastolic blood pressure was both found in group 1 (age 18–24 years); the figures were 1·4% and 1·2%, respectively.

7.3.3 Serum lipids

7.3.3.1 Total cholesterol

In the overall population (table 7.1), the highest prevalence of high total cholesterol was found in group 5 (age 55-64 years) and the second highest prevalence was found in group 4 (age 45-54 years). The lowest prevalence was found in group 1 (age 18-24 years).

The prevalence of high total cholesterol in men (table 7.2) and women (table 7.3) was 55.4% and 64.3%, respectively. For men, the highest (63.3%) and the second highest (59.0%) prevalence of high total cholesterol was found in group 5 and group 4, respectively. For women, the highest prevalence of high total cholesterol was found in group 5 and equaled 69.5%. The second highest prevalence of 67.4% was found in group 6. The lowest prevalence of high total cholesterol for both men and women was in group 1 and equaled 21.5% and 28.6%, respectively.

7.3.3.2 High-density lipoprotein cholesterol

In the overall population (table 7.1), the highest prevalence of low HDL was found in group 3 (age 35-44 years) and the second highest prevalence was found in group 2 (age 25-34 years). The lowest prevalence of HDL was found in group 6 (age 65-75 years).

The prevalence of low HDL in men (table 7.2) was almost three times higher than in women (table 7.3), at 23.0% and 8.1%, respectively. Men shared the same pattern as the overall population. The highest prevalence of low HDL in men was 29.8%, the second highest prevalence equaled 27.5% and the lowest one was 20.6%. In women, the highest prevalence of low HDL was found in group 2 (ages 25-34 years) and equaled 14.9%. Group 3 (ages 35-44 years) was the one with the second highest prevalence at 14%. The lowest prevalence occurred in group 6 (65-75 years old) and equaled 6.2%.

7.3.3.3 Low-density lipoprotein cholesterol

In the overall population (table 7.1), the highest prevalence of high LDL was found in group 5 (age 55-64 years), and the second highest prevalence was found in group 4 (age 45-54 years). The lowest prevalence was found in group 1 (age 18–24 years).

The prevalence of high LDL in men (table 7.2) and women (table 7.3) was 42.6% and 47.1%, respectively. For men, the highest prevalence of high LDL was found in group 4 (45-54 years old) at 50.8%. The second highest prevalence equaled 46.0% and occurred in group 5 (ages 55-64 years). For women, the highest prevalence was found in group 5 (ages 55-64 years) and equaled 50.6%. The second highest prevalence at 50% occurred in group 6 (ages 65-75 years). The lowest prevalence of high LDL for both men and women was found in group 1 (ages 18-24 years) and equaled 16.7% and 18.6%, respectively.

7.3.4 Comparison of outcomes

Significant differences exist between datasets in individual cardiovascular risk factors, and within different age groups, mostly due to sample size—the dataset from the NHS trust is at least ten times larger than the Nuffield Health dataset. The maximum could be up to 100 times. However, in terms of age and sex structures, the patterns are not similar.

In table 7.4, according to measurement of BMI, participants were more likely to be underweight in the Hampshire Health Record than in the Nuffield Health dataset (15.1% vs 3.4%). Men (table 7.5) had much higher likelihood than women (table 7.6) of being underweight in the Hampshire Health Record. Compared with participants aged 45–54 years (group 4) in Hampshire Health Record (table 7.4), those from Nuffield Health were more likely to be overweight, but less likely to be obese and morbidly obese. Men (table 7.5) and women (table 7.6) followed a similar pattern to that of the overall population (table 7.4) in terms of morbidly obese in Nuffield Health compared with those from the Hampshire Health Record. However, compared with participants aged 65–75 (group 6) in Hampshire Health Record (table 7.4), those in Nuffield Health were more likely to be overweight, but less likely to be obese and morbidly obese.

According to measurement of waist circumference, compared with individuals in the Hampshire Health Record (table 7.7), those from Nuffield Health were more likely to have high, but less likely to have very high waist circumference. Men (table 7.8) and women (table 7.9) followed a similar pattern to that of the overall population (table 7.7).

In terms of high blood pressure, compared with individuals in the Hampshire Health Record (table 7.10), those from Nuffield Health are less likely to have high systolic blood pressure. The pattern of high diastolic blood pressures is different in the Hampshire Health Record and Nuffield Health. Men (table 7.11) and women (table 7.12) followed a similar pattern to that of the overall population (table 7.10).

In terms of measurement of lipids (cholesterol, HDL and LDL), compared with participants aged 35–44 years (group 3) in the Hampshire Health Record (table 7.13), those from the Nuffield Health were less likely to have elevated total cholesterol, lower HDL, and elevated LDL. However, compared with participants aged 45–54 years (group 4), 55–64 years (group 5) and 65–75 years (group 6) in the Hampshire Health Record (table 7.13), those from Nuffield Health were more likely to have elevated total cholesterol and lower HDL, but less likely to have elevated LDL. Men aged 35–75 in the Hampshire Health Record (table 7.14) are less likely to have elevated total cholesterol and LDL, but more likely to have low HDL than those in Nuffield Health. Women (table 7.15) aged 35–44 years (group 3) in the Hampshire Health Record are more likely to have elevated total cholesterol, lower HDL, and elevated LDL than those in Nuffield Health; women aged 55–64 years (group 5) and 65–75 years (group 6) in the Hampshire Health Record are less likely to have elevated total cholesterol and LDL, but more likely to have low HDL than those in Nuffield Health.

Table 7.4: Comparison of prevalence of different body-mass index ranges between private dataset and public dataset in different age groups

	Underweight (%)			Overweight (%)			Obese (%)			Morbidly obese (%)		
	Public	Private	p value	Public	Private	p value	Public	Private	p value	Public	Private	p value
Group 1, age 18– 24years	15.1% n=7072	3.4% n=49	p<0.001	14.9% n=6977	21.4% n=305	p<0.001	7.2% n=3397	5.6% n=80	p<0.001	1.2% n=580	0.7% n=10	p<0.001
Group 2, age 25– 34 years	6.4% n=7417	2.1% n=229	p<0.001	22% n=25586	31.2% n=3478	p<0.001	10.9% n=12744	8.2% n=917	p<0.001	1.8% n=2141	0.4% n=45	p<0.001
Group 3, age 35– 44 years	2.8% n=3323	0.7% n=124	p<0.001	30.1% n=35820	41.7% n=7765	p<0.001	15.9% n=19009	15% n=2785	p<0.001	2.7% n=3171	0.8% n=140	p<0.001
Group 4, age 45– 54 years	1.6% n=1974	0.5% n=92	p<0.001	34.2% n=41571	44.9% n=7908	p<0.001	20.7% n=25152	18.3% n=3216	p<0.001	3.3% n=3953	0.9% n=161	p<0.001
Group 5, age 55– 64 years	1.5% n=1489	0.5% n=46	p<0.001	37% n=37441	48.1% n=4532	p<0.001	23.5% n=23819	19.7% n=1859	p<0.001	3.2% n=3282	0.9% n=82	p<0.001
Group 6, age 65– 75 years	1.6% n=1412	0.5% n=8	p<0.001	39.8% n=35988	51% n=808	p<0.001	23.5% n=21229	14.8% n=234	p<0.001	2.7% n=2416	0.6% n=9	p<0.001
Overall	3.8% n=22687	1% n=548	p<0.001	30.8% n=183383	41.4% n=24796	p<0.001	17.7% n=105350	15.2% n=9091	p<0.001	2.6% n=15543	0.7% n=447	p<0.001

Table 7.5: Comparison of prevalence of different body-mass index ranges between private dataset and public dataset in different age groups in men

	Underweight (%)			Overweight (%)			Obese (%)			Morbidly obese (%)		
	Public	Private	p value	Public	Private	p value	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	18.5% n=3508	1.9% n=12	p<0.001	13% n=2470	28.3% n=179	p<0.001	5.1% n=973	6.3% n=40	p<0.001	0.9% n=169	0.6% n=4	p<0.001
Group 2, age 25–34 years	6.1% n=2897	0.6% n=34	p<0.001	24.3% n=11578	42.1% n=2353	p<0.001	9.2% n=4370	9.3% n=520	p<0.001	1.2% n=544	0.3% n=19	p<0.001
Group 3, age 35–44 years	2.1% n=1169	0.2% n=22	p<0.001	35.8% n=19640	50.3% n=5722	p<0.001	15.2% n=8316	17.4% n=1984	p<0.001	1.5% n=846	0.6% n=70	p<0.001
Group 4, age 45–54 years	1% n=568	0.1% n=10	p<0.001	41.7% n=24066	53.1% n=6060	p<0.001	21.4% n=12367	20% n=2285	p<0.001	2.2% n=1278	0.6% n=73	p<0.001
Group 5, age 55–64 years	1% n=502	0.1% n=6	p<0.001	43.4% n=21326	53.8% n=3513	p<0.001	24.5% n=12054	21.3% n=1389	p<0.001	2.2% n=1065	0.6% n=42	p<0.001
Group 6, age 65–75 years	1.1% n=490	0.2% n=2	p<0.001	45.7% n=20178	57.6% n=604	p<0.001	23.2% n=10247	13.7% n=144	p<0.001	1.7% n=768	0.6% n=6	p<0.001
Overall	3.4% n=9134	0.2% n=86	p<0.001	36.4% n=99258	50.3% n=18431	p<0.001	17.7% n=48327	17.4% n=6362	p<0.001	1.7% n=4670	0.6% n=214	p<0.001

Table 7.6: Comparison of prevalence of different body-mass index ranges between private dataset and public dataset in different age groups in women

	Underweight (%)			Overweight (%)			Obese (%)			Morbidly Obese (%)		
	Public	Private	p value	Public	Private	p value	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	12.8% n=3564	4.7% n=37	p<0.001	16.2% n=4507	15.9% n=126	p<0.001	8.7% n=2424	5.0% n=40	p<0.001	1.5% n=411	0.8% n=6	p<0.001
Group 2, age 25–34 years	6.6% n=4520	3.5% n=195	p<0.001	20.4% n=14008	20.2% n=1125	p<0.001	12.2% n=8374	14.5% n=397	p<0.001	2.3% n=1597	0.5% n=26	p<0.001
Group 3, age 35–44 years	3.3% n=2154	1.4% n=102	p<0.001	25.1% n=16180	28.2% n=2043	p<0.001	16.6% n=10693	11.1% n=801	p<0.001	3.6% n=2325	1.0% n=70	p<0.001
Group 4, age 45–54 years	2.2% n=1406	1.3% n=82	p<0.001	27.4% n=17505	29.9% n=1848	p<0.001	20.0% n=12785	15.1% n=931	p<0.001	4.2% n=2675	1.4% n=88	p<0.001
Group 5, age 55–64 years	1.9% n=987	1.4% n=40	p<0.001	30.9% n=16115	35.2% n=1019	p<0.001	22.6% n=11765	16.2% n=470	p<0.001	4.3% n=2217	1.4% n=40	p<0.001
Group 6, age 65–75 years	2.0% n=922	1.3% n=6	p<0.001	34.2% n=15810	38.1% n=204	p<0.001	23.7% n=19982	16.8% n=90	p<0.001	3.6% n=1648	0.6% n=3	p<0.001
Overall	4.2% n=13553	2.0% n=462	p<0.001	26.0% n=84125	27.4% n=6365	p<0.001	17.6% n=57023	11.7% n=2729	p<0.001	3.4% n=10873	1.0% n=233	p<0.001

Table 7.7: Comparison of prevalence of high and very high waist circumference between private dataset and public dataset in different age groups

	High (%)			Very high (%)		
	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	11% n=80	11.4% n=135	p<0.001	20.4% n=149	7.4% n=87	p<0.001
Group 2, age 25–34 years	13.3% n=347	15% n=1483	p<0.001	23.4% n=611	10.2% n=1011	p<0.001
Group 3, age 35–44 years	18.4% n=561	23.2% n=4053	p<0.001	35.9% n=1097	17.9% n=3119	p<0.001
Group 4, age 45–54 years	20.1% n=925	26.0% n=4316	p<0.001	49.5% n=2204	23.8% n=3946	p<0.001
Group 5, age 55–64 years	21.8% n=1278	29.3% n=2631	p<0.001	55.8% n=3271	28.0% n=2514	p<0.001
Group 6, age 65–75 years	22.9% n=1780	30.4% n=459	p<0.001	57.0% n=4424	28.8% n=436	p<0.001
Overall	20.3% n=4971	23.5% n=13077	p<0.001	48.0% n=11756	20.0% n=11113	p<0.001

Table 7.8: Comparison of prevalence of high and very high waist circumference between private dataset and public dataset in different age groups in men

	High (%)			Very high (%)		
	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	8.1% n=24	9.2% n=58	p<0.001	6.1% n=18	5.5% n=35	p<0.001
Group 2, age 25–34 years	11.3% n=129	15.0% n=838	p<0.001	12.5% n=142	8.4% n=470	p<0.001
Group 3, age 35–44 years	19.6% n=301	23.8% n=2704	p<0.001	25.1% n=386	16.4% n=1862	p<0.001
Group 4, age 45–54 years	24.2% n=578	28.1% n=3210	p<0.001	41% n=978	21.8% n=2487	p<0.001
Group 5, age 55–64 years	24.9% n=820	30.1% n=2021	p<0.001	50.5% n=1665	26.2% n=1706	p<0.001
Group 6, age 65–75 years	26.9% n=1139	31.2% n=327	p<0.001	49.7% n=2101	25.6% n=268	p<0.001
Overall	23.2% n=2991	25.0% n=9158	p<0.001	41.0% n=5290	18.6% n=6828	p<0.001

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Table 7.9: Comparison of prevalence of high and very high waist circumference between private dataset and public dataset in different age groups in women

	High (%)			Very high (%)		
	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	12.9% n=56	14% n=77	p<0.001	30.3% n=131	9.0% n=52	p<0.001
Group 2, age 25–34 years	14.8% n=218	15.1% n=645	p<0.001	31.8% n=469	12.6% n=541	p<0.001
Group 3, age 35–44 years	17.2% n=260	22.2% n=1349	p<0.001	46.9% n=711	20.7% n=1257	p<0.001
Group 4, age 45–54 years	16.8% n=347	21.3% n=1106	p<0.001	59.4% n=1226	28.1% n=1459	p<0.001
Group 5, age 55–64 years	17.9% n=458	24.8% n=610	p<0.001	62.7% n=1606	32.8% n=808	p<0.001
Group 6, age 65–75 years	18.1% n=641	28.4% n=132	p<0.001	65.7% n=2323	36.1% n=168	p<0.001
Overall	17.1% n=1980	20.6% n=3919	p<0.001	55.8% n=6466	22.5% n=4285	p<0.001

Table 7.10: Comparison of prevalence of high blood pressure between private dataset and public dataset in different age groups

	high systolic blood pressure			high diastolic blood pressure		
	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	5.9% n=2573	2.2% n=31	p<0.001	1.2% n=612	1.8% n=25	p<0.001
Group 2, age 25–34 years	10.9% n=9887	2.9% n=325	p<0.001	3.4% n=4637	3.1% n=345	p<0.001
Group 3, age 35–44 years	20.7% n=24325	6.4% n=1198	p<0.001	7.5% n=10943	8.0% n=1485	p<0.001
Group 4, age 45–54 years	36.4% n=50905	12.1% n=2132	p<0.001	13.9% n=21207	12.4% n=2179	p<0.001
Group 5, age 55–64 years	51.6% n=98254	22.1% n=2090	p<0.001	14.6% n=19634	15.1% n=1420	p<0.001
Group 6, age 65–75 years	60.9% n=127914	32.5% n=515	p<0.001	15.0% n=17767	13.0% n=205	p<0.001
Overall	39.6% n=313858	13.1% n=6291	p<0.001	10.1% n=73809	9.5% n=5659	p<0.001

Table 7.11: Comparison of prevalence of high blood pressure between private dataset and public dataset in different age groups in men

	high systolic blood pressure			high diastolic blood pressure		
	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	12.7% n=974	3.8% n=24	p<0.001	1.4% n=236	2.8% n=18	p<0.001
Group 2, age 25–34 years	22.8% n=4486	4.9% n=276	p<0.001	5.0% n=2545	5.0% n=280	p<0.001
Group 3, age 35–44 years	33.0% n=12166	8.7% n=986	p<0.001	10.7% n=6821	10.8% n=1229	p<0.001
Group 4, age 45–54 years	43.4% n=26214	14.0% n=1604	p<0.001	16.6% n=11975	15.2% n=1738	p<0.001
Group 5, age 55–64 years	54.5% n=48488	39.6% n=1580	p<0.001	17.7% n=10943	17.6% n=1148	p<0.001
Group 6, age 65–75 years	60.1% n=60114	33.9% n=325	p<0.001	12.8% n=7353	13.5% n=141	p<0.001
Overall	48.6% n=152442	13.1% n=4795	p<0.001	12.3% n=39873	12.4% n=4554	p<0.001

Table 7.12: Comparison of prevalence of high blood pressure between private dataset and public dataset in different age groups in women

	high systolic blood pressure			high diastolic blood pressure		
	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	4.4% n=1599	0.9% n=7	p<0.001	1.2% n=361	0.9% n=7	p<0.001
Group 2, age 25–34 years	7.6% n=5401	0.9% n=49	p<0.001	2.4% n=1887	1.2% n=65	p<0.001
Group 3, age 35–44 years	15.1% n=12159	2.9% n=212	p<0.001	5.3% n=3991	3.7% n=256	p<0.001
Group 4, age 45–54 years	31.1% n=24691	8.5% n=528	p<0.001	9.4% n=7229	7.1% n=441	p<0.001
Group 5, age 55–64 years	49.1% n=49766	17.6% n=510	p<0.001	12.2% n=7695	9.4% n=272	p<0.001
Group 6, age 65–75 years	61.7% n=67800	35.5% n=190	p<0.001	10.8% n=6412	12.0% n=64	p<0.001
Overall	33.7% n=161416	6.4% n=1496	p<0.001	7.1% n=27575	4.8% n=1105	p<0.001

Table 7.13: Comparison of prevalence of raised total cholesterol, lower HDL cholesterol, and elevated LDL cholesterol between private dataset and public dataset in different age groups

HDL=high-density lipoprotein. LDL=low-density lipoprotein.

	Raised high cholesterol (%)			Lower HDL (%)			Elevated LDL (%)		
	Public	Private	p value	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	25.1% n=718	19.2% n=132	p<0.001	17.6% n=70	9.9% n=66	p<0.001	18.5% n=403	6.4% n=43	p<0.001
Group 2, age 25–34 years	36.2% n=4213	32.0% n=2046	p<0.001	24.6% n=311	17.6% n=1118	p<0.001	20.7% n=1757	7.5% n=482	p<0.001
Group 3, age 35–44 years	51.8% n=18715	51.0% n=7583	p<0.001	40.8% n=1755	34.7% n=5077	p<0.001	22.3% n=5933	10.7% n=1588	p<0.001
Group 4, age 45–54 years	61.0% n=61991	65.8% n=10749	p<0.001	46.2% n=5778	47.0% n=7538	p<0.001	19.4% n=14106	10.9% n=1775	p<0.001
Group 5, age 55–64 years	63.6% n=112036	70.0% n=6287	p<0.001	48.0% n=10728	51.2% n=4534	p<0.001	16.1% n=19954	10.6% n=954	p<0.001
Group 6, age 65–75 years	58.5% n=163714	64.5% n=993	p<0.001	43.4% n=15319	48.7% n=742	p<0.001	13.8% n=25958	9.0% n=138	p<0.001
Overall	59.4% n=361387	57.0% n=27790	p<0.001	44.6% n=33961	40.0% n=19075	p<0.001	16.2% n=68111	10.2% n=4980	p<0.001

Table 7.14: Comparison of prevalence of raised total cholesterol, lower HDL cholesterol, and elevated LDL cholesterol between private dataset and public dataset in different age groups in men
HDL=high-density lipoprotein. LDL=low-density lipoprotein.

	Raised total cholesterol (%)			Lower HDL (%)			Elevated LDL (%)		
	Public	Private	p value	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	21.5% n=296	18.3% n=33	p<0.001	24.1% n=35	13.9% n=26	p<0.001	16.7% n=255	14.4% n=25	p<0.001
Group 2, age 25–34 years	35.9% n=1963	39.2% n=1091	p<0.001	27.5% n=159	13.5% n=736	p<0.001	25.0% n=1082	26.9% n=377	p<0.001
Group 3, age 35–44 years	56.1% n=10737	59.7% n=5276	p<0.001	29.8% n=1065	15.8% n=3911	p<0.001	45.4% n=4180	45.5% n=1395	p<0.001
Group 4, age 45–54 years	63.3% n=36346	68.7% n=7230	p<0.001	25.9% n=3641	24.7% n=5469	p<0.001	50.8% n=10484	53.4% n=1594	p<0.001
Group 5, age 55–64 years	59.0% n=58632	66.0% n=4097	p<0.001	23.1% n=5833	14.4% n=3078	p<0.001	46.0% n=15909	50.5% n=894	p<0.001
Group 6, age 65–75 years	51.0% n=77515	58.6% n=597	p<0.001	20.6% n=7243	12.2% n=452	p<0.001	37.8% n=20556	45.0% n=124	p<0.001
Overall	55.4% n=185489	62.0% n=18324	p<0.001	23.0% n=17976	15.0% n=13672	p<0.001	42.6% n=52466	47.4% n=4409	p<0.001

Table 7.15: Comparison of prevalence of raised total cholesterol, lower HDL cholesterol, and elevated LDL cholesterol between private dataset and public dataset in different age groups in women
HDL=high-density lipoprotein. LDL=low-density lipoprotein.

	Raised total cholesterol (%)			Lower HDL (%)			Elevated LDL (%)		
	Public	Private	p value	Public	Private	p value	Public	Private	p value
Group 1, age 18–24 years	28.6% n=422	20.3% n=99	p<0.001	13.2% n=35	3.7% n=40	p<0.001	18.6% n=148	8.2% n=18	p<0.001
Group 2, age 25–34 years	36.5% n=2250	26.4% n=955	p<0.001	14.9% n=152	2.9% n=382	p<0.001	24.2% n=675	10.6% n=105	p<0.001
Group 3, age 35–44 years	46.9% n=7978	38.2% n=2307	p<0.001	14.0% n=690	3.2% n=1166	p<0.001	35.3% n=1753	19.4% n=193	p<0.001
Group 4, age 45–54 years	58.0% n=25645	60.6% n=3519	p<0.001	11.3% n=2137	3.2% n=2069	p<0.001	40.1% n=3622	35.8% n=181	p<0.001
Group 5, age 55–64 years	69.5% n=53404	82.7% n=2190	p<0.001	7.3% n=4895	2.2% n=1456	p<0.001	50.6% n=4045	52.8% n=60	p<0.001
Group 6, age 65–75 years	67.4% n=86199	76.0% n=396	p<0.001	6.2% n=8076	2.7% n=290	p<0.001	50.0% n=5402	55.7% n=14	p<0.001
Overall	64.3% n=175898	49.2% n=9466	p<0.001	8.1% n=15985	3.0% n=5403	p<0.001	47.1% n=15645	28.2% n=571	p<0.001

7.4 DISCUSSION

Overall (table 7.1), about one in two people are overweight or obese in the Hampshire Health Record. Nearly 40% of individuals had high systolic blood pressure, but only 10% had high diastolic blood pressure. About 60% and 45% of participants had elevated total cholesterol and LDL, respectively, and about 16% of participants had lower HDL.

Although overweight and obesity gained more attention, underweight among adolescents might also be a problem in developed countries. In individuals aged 18–24 years in this study (Hampshire Health Record), about one in seven was likely to be underweight. Although the prevalence of underweight is higher and participants are much older compared with the East of England Healthy Heart Study (5.9%), in which Ogunleye and colleagues (2013) examined BMI data for 9614 schoolchildren aged 9–16 years, much attention is needed on the issue of underweight in children and adolescents; this is a problem not only in the developing world, but is also happening in developed countries, and girls need more attention than boys because they are more likely to be underweight. Much attention has been focused on the rapid rise in the percentages of children who are overweight and obese, and their associated health problems. Factors responsible for a child being underweight could include rising food prices, a poor diet, and fear of being overweight or obese (Save the Children 2012; Treasure *et al.* 2010). Low muscle mass due to lack of exercise could also contribute to being underweight (Luder and Alton 2005). Ogunleye and colleagues noted that recent findings suggest that half of doctors in England and Wales lack knowledge on how to measure for underweight in children, and there is a need for more training for GPs and policies supporting parents and educating them about healthy diet and levels of exercise for their children.

Individuals in Nuffield Health were more likely to be overweight, but less likely to be obese than were those from the Hampshire Health Record. However, participants aged 18–24 years in the Hampshire Health Record were more likely to be underweight than were those from Nuffield Health. This is different from what we already know—ie, that people from higher socioeconomic groups have better cardiovascular health in developed countries. Several factors—genetics,

behaviour and lifestyle change, social determinants, low birthweight, urbanisation, diet, physical activity, psychological stress—could contribute to this effect in this study.

Individuals aged between 55 and 75 years had more cardiovascular risk factors than those younger than 55 years. Age is a non-modifiable cardiovascular risk factor. Ageing is an inevitable part of life and unfortunately poses the largest risk factor for cardiovascular disease. Over 80% of all cardiovascular deaths occur in this age group (age 55–75 years). It is estimated that almost one in four individuals will be older than 65 years by the year 2035 in the USA. About 10 million people in the UK are older than 65 years. The latest projections are for 5.5 million more elderly people in 20 years' time, and the number will have nearly doubled to around 19 million by 2050. In this regard, quantitative information about age-associated changes in cardiovascular structure and function in health is essential in order to define and target the specific characteristics of the cardiovascular ageing process.

Clinical manifestations and prognosis of cardiovascular diseases are likely to become altered with advanced age because interactions occur between age-associated cardiovascular changes in health and specific pathophysiological mechanisms that underlie disease. A fundamental understanding of age-associated changes in cardiovascular structure and function, ranging in scope from human beings to molecules, is needed for effective and efficient prevention and treatment of cardiovascular disease in older individuals. Although numerous studies in the cardiovascular field have considered both young and old individuals, there are still many unanswered questions as to how the genetic pathways that regulate ageing in model organisms affect cardiovascular ageing. Likewise, in the field of molecular biology of ageing, few studies fully assess the role of these ageing pathways in cardiovascular health. Fortunately, this gap is beginning to close, and these two fields are merging together.

It was anticipated that the population from the NHS dataset would have a lower or much the same BMI than those from the Nuffield Health dataset. However, women had a lower BMI in the Nuffield Health dataset. Also, although many risk factors contribute to cardiovascular diseases in both men and women, the cardiovascular risk factors for women are the same as those in men,

such as cigarette smoking, elevated serum cholesterol, elevated blood pressure, and a sedentary lifestyle (Johnson 1977; Kannel 1987; Pajak *et al.* 1988; Petitti 1979; Waters *et al.* 1978). However, the effect of individual risk factors might differ between men and women, and women were more likely to have cardiovascular risk factors than men (Jousilahti *et al.* 1999; Njolstad *et al.* 1996).

Most deaths due to cardiovascular disease could be prevented through lifestyle changes. Identification of people with medical risks (eg, diabetes, high blood pressure, high cholesterol, familial hypercholesterolaemia, previous cardiovascular disease event) and ensuring they receive effective treatment will help to reduce mortality due to cardiovascular disease. *Fair Society, Healthy Lives* notes that only 4% of NHS funding is currently spent on prevention. In view of the health burden attributable to risk factors, there is a clear case for arguing for this proportion to be increased. This is not new: the final report of the review led by Sir Derek Wanless (2007) looking at the resources needed to provide high-quality health services in the future projected that a substantial reduction in costs could be achieved by an increased emphasis on prevention, coupled with higher levels of public engagement in relation to their health.

Although this study did not include assessment of vegetable and fruit intake for the effect on cardiovascular disease and its associated risk factors, several prospective studies have directly related fruit and vegetable intake to cardiovascular disease and showed a causal effect. In a 5-year follow-up study of 1273 Massachusetts residents aged no less than 65 years, Gaziano and colleagues (1995) used a 43-item semiquantitative food-frequency questionnaire (SFFQ) to assess participants' average dietary intakes in the previous year and related vegetable intake to subsequent cardiovascular death. The authors found that residents whose reported intake of carotene-containing fruit or vegetables was in the highest quartile had a 46% lower risk of death from cardiovascular disease than did residents whose reported intake was in the lowest quartile. In a 14-year follow-up study of 5133 Finnish adults, Knekt and colleagues (1994) assessed vegetable intake with a dietary history method and found a relative risk of 0.66 ($p=0.02$) for coronary mortality when comparing the highest and lowest tertiles of vegetable intake. As pointed out by Ness and Powles (1997), the causal link between fruit and vegetable intake and risk of

cardiovascular disease has been more assumed than actually shown. In future study, data for fruit and vegetable intake should be collected through a standard questionnaire, such as the SFFQ.

Social, economic, and political determinants as well as lifestyle and behaviours have been widely accepted as the major drivers of the current global epidemic of cardiovascular disease. After the UN High Level meeting in September, 2011, the whole world is now working hard to implement the Political Declaration by promoting the “whole government strategy” and “whole society strategy” to reduce the key risk factors and promote a healthy lifestyle. Eating plenty of fruit and vegetables reduces the chance of developing a range of health problems. Modelled estimates indicate that the highest percentages of adults eating healthy diets are found in several London boroughs and in parts of the south east and east of England. Recent estimates suggest that fruit and vegetable consumption increases with age, but that even among those aged 65 years and over, the average “5 A Day” portions consumed is 4.4. Only 10% of those aged 11–18 years achieve the recommended number of “5 A Day” portions, compared with 30% of those aged 19–64 years, and 37% of those aged 65 years and over.

However, it is also necessary to avoid high levels of energy intake without sufficient physical activity. Physical activity includes all forms of exercise such as walking, cycling, active play, work-related activity, active recreation and organised sport, dancing, gardening, or playing active games. A physically active lifestyle can reduce the risk of many chronic conditions including coronary heart disease, stroke, type 2 diabetes, some cancers, obesity, mental health problems, and musculoskeletal conditions. Excessive sugar intake is a particular concern, but is often only one source of unhealthy energy intake. High levels of salt consumption are associated with an increase in blood pressure, which is a risk factor for heart disease and stroke. Diets high in saturated fat also increase cholesterol levels, another heart disease risk factor. The benefits of being active are present across the life course.

For adults, the corresponding recommendation is for 150 minutes of moderate intensity activity over a week, or the equivalent of vigorous activity. Structured exercise and school sport can make an important contribution to an individual’s physical activity. The direct cost of physical inactivity

to the NHS across the UK is estimated to be £1.06 billion. There is evidence that action at multiple levels is effective in increasing physical activity levels, from primary care professionals encouraging individuals to lead active lives, to local authorities investing in community-level activity programmes and employers promoting active workplaces. All age groups should aim to be active daily and minimise the amount of time spent being sedentary for extended periods. There is a marked reduction in the percentage meeting the appropriate activity level as age increases. In 2008, an average of 39.2% of men and 28.7% of women reported they were active to at least the recommended level, with the percentage falling progressively from 44.5% of 16–24 year olds to 7.3% of those aged 75 years and over. The percentage of active adults has increased from 26.1% in 1997 to 33.8% in 2008, but this rise should be seen in the context of a long-term decline in walking and cycling for travel purposes.

Ethnicity is an issue. White Caucasians mainly dominated Nuffield Health's dataset, which indicates a greater genetic risk of cardiovascular diseases. A higher risk of premature death and poor health attributed to cardiovascular disease has been reported in Irish, Scottish, and South Asian groups, particularly Pakistani and Bangladeshi populations (Aspinall and Jacobson 2004; Bardsley *et al.* 2000; Britton *et al.* 2004; Harding and Balarajan 1996; Harding and Maxwell 1997). The mortality rate from coronary heart disease is 50% higher in people born in Bangladesh, India, and Pakistan than among the general population (Healthcare Commissioning 2005). The Black Caribbean population has lower premature death rates from coronary heart disease than the general population (Abbotts *et al.* 2004). It was speculated that more Africans are likely to work in the public sector, and access NHS services, and a larger proportion of South Asian (mainly Indian) people are more affluent, therefore, the results might be different from previous studies.

Private hospitals now receive 28% of their income from treating NHS patients (CHPI 2014). They also rely on NHS hospitals to treat many of those who develop complications whilst being treated in private hospitals. Also, around 6,000 patients a year are admitted to the NHS from private hospitals (CHPI 2014). However, the standards of confidentiality applied in accordance with data protection law and confidentiality, anonymous or aggregated data are provided by Nuffield Health

and Hampshire Health Record for my research, this was not able to be checked. It should be noted as a limitation of the study.

7.5 CONCLUSIONS

Two datasets (from Nuffield Health and Hampshire Health Record) seem to be comparable. One would assume that many aspects—the effect of adult lifestyle, potential genetic differences, developmental conditions throughout the lifecourse, per se and operating through social determinants, rapid urbanisation, androgen level, low birthweight, limited childhood living condition, low-carbohydrate high-protein diet, collectivist society, psychological stress—could have an effect on the similarities and the outcomes in this study. However, according to the findings from these two datasets, people aged 55–64 and 65–75 years who have signed up to private medical insurance (Nuffield Health) and in south England (from the Hampshire Health Record) were more likely to be overweight and obese; to have hypertension, elevated total cholesterol and LDL, and low HDL.

These people may have to care more about their lifestyle and diet, and exercise more. Structured exercise and school sport can make an important contribution to an individual's physical activity. A physically active lifestyle can reduce the risk of many chronic conditions including coronary heart disease, stroke, obesity, and mental health problems. There is evidence that action at multiple levels is effective in increasing physical activity levels, from primary care professionals encouraging individuals to lead active lives, to local authorities investing in community-level activity programmes and employers promoting active workplaces. Policy makers should also act on this evidence to adjust their guidelines at a regional level.

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CHAPTER 8:

COMPARISON OF EFFECT OF CARDIOVASCULAR RISK FACTORS IN DIFFERENT SOCIOECONOMIC GROUPS PROVIDED BY NUFFIELD HEALTH AND HAMPSHIRE HEALTH RECORD

ABSTRACT

Aim: This chapter aims to examine the association between area-level deprivation and objectively measured, modifiable cardiovascular risk factors in a socioeconomic affluent population who attended the public NHS, and then to compare the findings with those of Chapter 5.

Methods: Data were provided by Hampshire Health Record, NHS Hampshire. Seven risk factors were analysed: body-mass index (BMI), waist size, systolic and diastolic blood pressure, total, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol. The Index of Multiple Deprivation 2007 was used as a proxy indicator of socioeconomic circumstances of residents in neighbourhoods. This was used to compare the different risk factors from the least deprived to the most deprived areas in the region. Linear regressions were done to investigate the impact of deprivation on different modifiable cardiovascular risk factors, as measured in people attending Hampshire Health Record. The association between deprivation (groups) and cardiovascular risk factors was evaluated by the odds ratios for deprivation alone, and after adjustment for age and sex. Both results are compared in the statistical analysis

Results: Age-corrected and sex-corrected odds for obesity, both BMI and waist circumference, decreased significantly with socioeconomic index, and the least deprived groups had the lowest likelihood of being obese (group 5 [BMI]: odds ratio 0.60, 95% CI 0.59–0.62, $p < 0.001$; [waist circumference]: odds ratio 0.64, 95% CI 0.59–0.69, $p < 0.001$), compared with the most deprived groups. Adjusted odds ratio for high systolic blood pressure was significantly higher in participants from group 2 (odds ratio 1.04, 95% CI 1.01–1.65, $p = 0.002$) and group 3 (odds ratio 1.02, 95% CI 1.00–1.05, $p = 0.041$), and lowest in group 4 (odds ratio 0.98, 95% CI 0.96–1.01). Adjusted odds ratio for high diastolic blood pressure was significantly lower in the two least deprived groups

(group 4: odds ratio 0.95, 95% CI 0.92–0.98, $p=0.004$; group 5: odds ratio 0.95, 95% CI 0.92–0.98, $p=0.002$), compared with the most deprived groups. There was a general trend towards a general higher likelihood of plasma cholesterol in the least deprived groups, and there is significant between-group differences in the likelihood of having elevated total cholesterol and LDL, as well as low HDL. Greater adiposity was found in people from more deprived groups in data from both Hampshire Health Record and Nuffield Health estimated by two measures: BMI and waist circumference. Findings also showed that the likelihood of having high blood pressure, however, was lower in the two most deprived areas than the other least deprived area. The likelihood of having high total cholesterol and LDL, and low HDL, was significantly higher in the least deprived groups. Compared with data from Nuffield Health, adiposity (BMI and waist circumference), blood pressure (systolic and diastolic), and total cholesterol shared the same trend with Hampshire Health Record data, and the likelihood of having high LDL and lower HDL were lower in two more deprived groups between two datasets.

Discussion: This is the first study to compare participants both from a private health-care company and the public-funded NHS. It provides a unique opportunity to open the research arena and note the outcomes from these comparable groups. This research also confirmed the previous findings from Chapter 5 that the two datasets are comparable. Our results might not only be generalisable to other commercially insured populations, but also to some affluent areas in the UK. Although many studies have assessed the association between socioeconomic status and cardiovascular risk factors, those studies were on the basis of a much smaller sample size than was used in this study, so the results are not as reliable and generalisable as those of this study.

Conclusion: These findings showed that socioeconomic deprivation is a strong and independent predictor, and it has an effect in the development of cardiovascular risk factors in people living in the south central England region. Although two datasets are comparable, those living in the south central England region were more likely to develop obesity and hypertension, but less likely to have elevated cholesterol and LDL, as well as low HDL, compared with those from Nuffield Health. The south central England region has a higher proportion of ageing population, and the area is more affluent than national average, this could explain the above findings. Therefore,

regional preventive policy should focus on these higher prevalent cardiovascular risk factors, especially the high risk population in the region. Simple diet policy initiatives in the region could achieve corresponding falls in cardiovascular deaths. Evidence-based population-wide policy interventions exist, and these interventions should now be urgently implemented to effectively tackle persistent inequalities.

8.1 INTRODUCTION

Non-communicable diseases (NCDs)—cardiovascular diseases, diabetes, chronic respiratory diseases, and cancer—kill more than 36 million people per year worldwide. Cardiovascular diseases alone are responsible for most NCD deaths, causing an estimated 17.3 million annual deaths (Lim *et al.* 2012). In England in 2007, cardiovascular disease contributed to more than 150 000 deaths, accounting for nearly 34% of all deaths in England (British Heart Foundation 2009). In a recent paper in *The Lancet*, Chris Murray and colleagues (2013) assessed the UK's health performance and reported that the first ranked cause of years-of-life-lost due to premature mortality (YLLs) in the UK in 2010 was ischaemic heart disease and the third ranked was stroke. Hypertension has been identified as the major risk factor for this large burden, exceeding that for alcohol and high body-mass index (BMI).

Cooney and colleagues (2009) re-evaluated the Rose approach—population preventive measures—and pooled data from six European cohorts involving more than 100 000 participants. This analysis compared the estimated effects of population strategies at varying levels of population-wide risk factor reduction and high-risk strategies at varying rates of screening uptake on cardiovascular disease mortality. The study showed that a 10% reduction in blood pressure, cholesterol, and prevalence of smoking would save 9125 lives per million of the population saved over 10 years; by contrast, treating 40% of high-risk individuals with a polypill—containing a statin, three half-dose anti-hypertensives, and aspirin—about 3720 lives per million would be saved, even assuming complete, long-term adherence. Also, Unal and colleagues (2005) used the cell-based IMPACT model to synthesise data for the adult population of England and Wales to estimate the proportions attributable to changes in major cardiovascular risk factors in apparently healthy people (primary prevention) and in patients with coronary heart disease (secondary prevention). Between 1981 and 2000, total cholesterol concentrations fell by 4.2%, resulting in approximately 5770 fewer deaths attributable to dietary changes (1205 in patients with coronary heart disease and 4565 in healthy people), whereas mean blood pressure fell by 7.7%, resulting in approximately 5870 fewer deaths attributable to secular falls in blood pressure (520 in patients with coronary heart disease and 5345 in healthy people). Approximately 45 370 fewer deaths were

thus attributable to reductions in the three major risk factors—smoking, cholesterol, and blood pressure—in the population.

Reducing the risks—such as by quitting smoking or changing diet—could reduce cholesterol or blood pressure, which would therefore lead to reduction of development of cardiovascular disease. Some population-based prevention programmes have been accompanied by a substantial reduction in the rate of cardiovascular disease mortality. Evidence found that 45–75% of the reduction in cardiovascular deaths in Westernised industrialised countries was on the basis of the reduction in major risk factors—smoking, salt intake, and saturated fat (NICE 2010). Intervention programmes targeted at reduction of major cardiovascular risk factors, such as blood pressure and cholesterol, by use of a healthy diet, have been shown to be highly effective (Appel *et al.* 1997; de Lorgeril *et al.* 1999). Population-based interventions aim to change the risks from the social, economic, material, and environmental factors that affect the entire population. This could be achieved through regulation, legislation, subsidy, and taxation or rearranging the physical layout of communities.

In 2010, 35% of deaths in men, and 16% in women, from cardiovascular disease occurred in people younger than 75 years, although the premature mortality rate from cardiovascular disease fell by 36% between 2001 and 2010 in the UK. The key risk factors for cardiovascular disease that can be modified are smoking, unhealthy diet, obesity, physical inactivity, and high alcohol consumption (Emberson *et al.* 2004; Yusuf *et al.* 2004). Cardiovascular risk factors tend to cluster together—ie, people who have hypertension are more likely to have a poor diet and physical inactivity—and have an uneven effect in socially disadvantaged groups, which further increases health inequalities. For instance, premature death rates are up to six times higher in lower socioeconomic groups than in more affluent groups in Scotland (O’Flaherty *et al.* 2009). In addition, South Asian groups have approximately 50% higher likelihood of death rates from cardiovascular disease than do the white population (Allender *et al.* 2007). Cardiovascular mortality varies geographically by local authority, with the highest rate 2·5 times that of the lowest. There is a clear north–south divide, and rates are 1·4 times higher in the most deprived areas than in the least deprived.

The prevalence of obesity and overweight continues to rise in the UK (National Heart Forum 2010). An overweight person of average height will increase their risk of death by appropriately 30% for every 15 additional kilograms of weight. In ten European countries, the odds of disability, defined as a limitation in activities of daily living (ADL), are almost twice as large among the obese as in normal weight people (Sassi 2010). The disease burden associated with overweight and obesity is considerable: the cost to the UK's National Health Service has been estimated to be £3.2 billion per year (Allender and Rayner 2007). The association between socioeconomic status and obesity is complex. When economies become more developed, socially disadvantaged groups are more likely to be affected in these economies. A particularly important socioeconomic factor linked to obesity is education, which showed some extent of association between higher education and a lower likelihood of obesity. This might help in tackling the obesity epidemic by increasing general school education and supporting the delivery of health and lifestyle education, or both (Sassi 2010).

At present, several area-based indices have sought to measure socioeconomic deprivation as distinct from individual socioeconomic position (Payne *et al.* 2009; Stewart *et al.* 2009; Townsend 1987). Deprivation indices are easier to apply in clinical practice than are most other measurements of socioeconomic status (Blakely *et al.* 2002) and have consequently become popular among public health researchers. This is because information about individual measures of socioeconomic status may be incomplete and potentially inaccurate. When employed as a dependent measure, deprivation indices provide a way by which routine population-based primary care data can be used to examine the effects of socioeconomic deprivation in determining cardiovascular risk factors.

Cardiovascular risk factors and the prevalence of cardiovascular disease itself are both associated with deprivation or analogous measures such as socioeconomic status. In Chapter 5, the association between area-level deprivation and objectively measured, modifiable cardiovascular risk factors in a non-clinical UK population who attended Nuffield Health, a private health-care insurance company, was examined. People who attended Nuffield Health are more likely to be of higher

socioeconomic class due to the requirement to pay for this service. The south central England region is relatively affluent compared with the national average. It is possible to compare the population who attended Nuffield Health with those located in the south central England region in terms of socioeconomic status, and validate the findings from Chapter 5. The aim of this Chapter is, therefore, to examine the association between area-level deprivation and objectively measured, modifiable cardiovascular risk factors in a socioeconomic affluent population who attended the public NHS, and then to compare the findings with those of Chapter 5.

8.2 DESIGN AND METHODS

8.2.1 Study setting and data collection

Data were provided by Hampshire Health Record, NHS Hampshire. The Hampshire Health Record is a joint project supported by Basingstoke and North Hampshire Foundation Trust, Hampshire Primary Care Trust, Portsmouth City Teaching Primary Care Trust, Portsmouth Hospitals NHS Trust, Southampton City Primary Care Trust, Southampton University Hospitals NHS Trust and Winchester and Eastleigh Hospital NHS Trust. Hampshire Health Record provides a detailed record of care that contains most of the information held in the general practitioner's (GP) record. It is stored by using a coding scheme (called READ Codes), which enables the data to be easily processed and displayed, whilst ensuring the quality and accuracy of the data is of a suitable level. Using this coding system means that only clinical data is shared and any comments the GP may record for their own use are not shared. The amount of information varies between patients, but normally includes information about allergies, medications, diagnosis, tests, and treatments.

8.2.2 Individual-level cardiovascular risk factors

Several established cardiovascular risk factors represent the risk profile of the participants: (1) anthropometric characteristics; (2) blood pressure; and (3) plasma serum. Obesity was examined by BMI and waist circumference, separately. BMI was classified as obese if over 30 kg/m². Waist circumference was measured at the anatomical waist, central obesity was defined as greater than 102 cm in men and greater than 88 cm in women. Hypertension was classified as greater than 90 mm Hg (diastolic) and greater than 140 mm Hg (systolic; NICE 2011). Plasma serum includes total, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol. Arterial blood was drawn and analysed. Total cholesterol, LDL subfraction, and HDL subfraction were measured. Total cholesterol was classified as raised if higher than 6.0 mmol/L. HDL was classified as low if less than 1.0 mmol/L; LDL was defined as raised if greater than 3.36 mmol/L (Contois *et al.* 1996).

8.2.3 Individual-level covariates

Age and sex were adjusted in all multivariate analyses. Age was defined as a continuous variable.

8.2.4 Area-level socioeconomic status

The Index of Multiple Deprivation 2007 (Noble *et al.* 2008), using postal code of residence to transfer to a deprivation score, was used as a proxy indicator of socioeconomic circumstances of residents in neighbourhoods. This was used to compare the different risk factors from the least deprived to the most deprived areas in the region. These area-level indices can be used to contrast disadvantaged areas or populations (Carstairs *et al.* 1995; DETR Indices of Deprivation 2000; Morris *et al.* 1991). The Indices were established to capture the multidimensional concept of socioeconomic deprivation and are based on various indicators within seven distinct domains— income, employment, health and disability, living environment, crime, barriers to housing and services, and education, skills, and training. A total of 38 indicators are distributed across these seven domains, with the aim of measuring both financial resources and consequent outcomes. The

English Indices of Deprivation 2007 scale was used to allocate deprivation scores on the basis of postcode, and the cohort was divided by quintile (group 1 being the least deprived and group 5 being the most deprived). This was used to compare the different risk factors from the least deprived to the most deprived areas.

8.2.5 Statistical analysis

Descriptive statistics were generated. Binary logistic regressions were performed to investigate the impact of deprivation on different modifiable cardiovascular risk factors, as measured in people attending Hampshire Health Record. The association between deprivation (groups) and cardiovascular risk factors was evaluated by the odds ratios after adjustment for age, sex and deprivation. Both results are compared in the statistical analysis. Data from this study were analysed using SPSS Version 17.0 (SPSS, Inc., Chicago, IL, USA). All baseline data were analysed at a 0.05 α level to determine statistical significance.

8.3 RESULTS

8.3.1 Descriptive statistics for the Nuffield dataset in different measures

Seven datasets contain various variables—BMI, waist circumference, total cholesterol, HDL, LDL, systolic blood pressure, and diastolic blood pressure—have been provided and analysed separately. Record numbers in each dataset are different, ranging from over 40 000 to around 1 million. Participants who accessed local GP centres in the south central England region were selected for analyses. Demographic and clinical characteristics of the population in different deprivation groups in the format of mean and standard deviation (SD) values are shown in Table 8.1.

Table 8.1: Demographic and clinical characteristics of the population in different deprivation groups (mean and SD) in public dataset

	Group 1 (most deprived)	Group 2	Group 3	Group 4	Group 5 (least deprived)
Demographic characteristics					
BMI (kg/m ²)	26.23 (6.62)	26.26 (6.30)	25.94 (6.01)	25.86 (5.73)	25.76 (5.44)
Waist	91.8 (27.24)	93.6 (22.96)	92.8 (21.44)	93.7 (20.26)	94.3 (17.99)
Clinical characteristics					
SBP	134 (21.42)	135 (21.53)	136 (21.54)	137 (21.43)	137 (21.25)
DBP	75 (10.21)	75 (10.047)	75 (10.09)	76 (9.98)	76 (9.97)
Cholesterol (mmol/l)					
Total	4.9 (1.12)	4.9 (1.10)	5.0 (1.10)	5.0 (1.08)	5.1 (1.08)
HDL	1.3 (0.39)	1.3 (0.40)	1.4 (0.41)	1.4 (0.43)	1.4 (0.43)
LDL	2.9 (1.20)	3.1 (1.17)	3.1 (1.15)	3.2 (1.10)	3.2 (1.08)

8.3.2 Anthropometric characteristics

Socioeconomic deprivation was significantly associated with BMI and waist circumference. Multiple logistic regression models were constructed to assess the effects of socioeconomic deprivation on the effect of BMI and waist circumference. Table 8.2 shows the odds ratio for socioeconomic deprivation in relation to BMI and waist circumference after adjusting for age and sex.

In multivariate models, females were more likely to be obese (odds ratio 1.16, 95% CI 1.15–1.18, $p < 0.001$) and centrally obese (odds ratio 1.88, 95% CI 1.79–1.96, $p < 0.001$) than were men. Compared with the most deprived group, all other groups had a lower likelihood of high age-adjusted and sex-adjusted BMI and waist circumference.

Table 8.2: Anthropometric characteristics (BMI and waist circumference) after adjusted for age and sex and deprivation groups (odds ratio and 95% CI) in public dataset

Risk factors	Number of people	Model	
		Odds ratio (95% CI)	p value
BMI (obese)			
Deprivation groups	602 605		
Group 1 (most deprived)	40 980	1.00	
Group 2	77 306	0.94 (0.91–0.96)	0.000
Group 3	116 360	0.79 (0.77–0.81)	0.000
Group 4	131 066	0.68 (0.66–0.70)	0.000
Group 5 least deprived)	236 893	0.60 (0.59–0.62)	0.000
Sex			
Male		1.00	
Female		1.16 (1.15–1.18)	0.000
Age		1.027 (1.026–1.027)	0.000
Waist circumference (obese)			
Deprivation groups	41 981		
Group 1 (most deprived)	4304	1.00	
Group 2	7185	0.86 (0.79–0.94)	0.000
Group 3	8077	0.76 (0.70–0.84)	0.000
Group 4	8999	0.69 (0.64–0.76)	0.000
Group 5 (least deprived)	13 416	0.64 (0.59–0.69)	0.000
Sex			
Male		1.00	
Female		1.88 (1.79–1.96)	0.000
Age		1.023 (1.022–1.023)	0.000

BMI=body-mass index.

8.3.3 Blood pressure measurements

Table 8.3 shows the odds for hypertension according to level of deprivation after adjusting for age and sex. Adjusted odds ratios for high systolic blood pressure were statistically highest in participants from group 2 (odds ratio 1.04, 95% CI 1.01–1.65, $p=0.002$) and lowest in group 4 (odds ratio 0.98, 95% CI 0.96–1.01). Adjusted odds ratios for high diastolic blood pressure were significant lower in participants from the two least deprived quintiles (group 4: odds ratio 0.95, 95% CI 0.92–0.98, $p=0.004$; and group 5: odds ratio 0.95, 95% CI 0.92–0.98, $p=0.002$).

In multivariate models, females were less likely to have elevated systolic blood pressure but more likely to have elevated diastolic blood pressure than were males (odds ratio 0.62, 95% CI 0.61–0.63, $p<0.001$; and odds ratio 1.29, 95% CI 1.28–1.30, $p<0.001$).

Table 8.3: Blood pressure (systolic and diastolic) after adjusted for age, sex and deprivation groups (odds ratio and 95% CI) in public dataset

Risk factors	Number of people	Model	
		Odds ratio (95% CI)	p value
High diastolic blood pressure			
Deprivation groups	843 564		
Group 1 (most deprived)	51 849	1.00	
Group 2	97 097	0.98 (0.95–1.02)	0.375
Group 3	163 075	1.00 (0.96–1.03)	0.866
Group 4	189 180	0.95 (0.92–0.98)	0.004
Group 5 (least deprived)	342 363	0.95 (0.92–0.98)	0.002
Sex			
Male		1.00	
Female		0.62 (0.61–0.63)	0.000
Age		1.014 (1.014–1.015)	0.000
High systolic blood pressure			
Deprivation groups	1 045 281		
Group 1 (most deprived)	46 307	1.00	
Group 2	107 041	1.04 (1.01–1.65)	0.002
Group 3	203 418	1.02 (1.00–1.05)	0.041
Group 4	225 591	0.98 (0.96–1.01)	0.150
Group 5 (least deprived)	462 924	0.99 (0.97–1.01)	0.275
Sex			
Male		1.00	
Female		1.29 (1.28–1.30)	0.000
Age		1.051 (1.051–1.051)	0.000

8.3.4 Plasma cholesterol measurements

Table 8.4 shows the odds ratios for raised total and LDL cholesterol or low HDL cholesterol according to deprivation after adjusting for age and sex. Compared with the most deprived group, all other groups had a greater likelihood of age-adjusted and sex-adjusted raised total cholesterol and LDL cholesterol and low HDL cholesterol.

In multivariate models, females were more likely to have raised total cholesterol and LDL than were males (odds ratio 1.68, 95% CI 1.67–1.69, $p < 0.001$; and odds ratio 1.37, 95% CI 1.34–1.41, $p < 0.001$), and more likely to have low HDL (odds ratio 3.56, 95% CI 3.50–3.61, $p < 0.001$).

Table 8.4: Plasma cholesterol (total cholesterol, HDL, and LDL) after adjusted for age sex and deprivation groups (odds ratio and 95% CI) in public dataset

Risk factors	Number of people	Model	
		Odds ratio (95% CI)	p value
High total cholesterol			
Deprivation groups	1 002 618		
Group 1 (most deprived)	45 140	1.00	
Group 2	98 825	1.08 (1.06–1.11)	0.000
Group 3	176 798	1.20 (1.18–1.23)	0.000
Group 4	235 484	1.38 (1.35–1.41)	0.000
Group 5 (least deprived)	446 371	1.46 (1.43–1.49)	0.000
Sex			
Male		1.00	
Female		1.68 (1.67–1.69)	0.000
Age		0.993 (0.992–0.993)	0.000
Low HDL			
Deprivation groups	630 789		
Group 1 (most deprived)	28 212	1.00	
Group 2	60 007	1.26 (1.21–1.30)	0.000
Group 3	112 502	1.55 (1.50–1.60)	0.000
Group 4	147 689	1.94 (1.88–2.00)	0.000
Group 5 (least deprived)	282 379	2.33 (2.26–2.40)	0.000
Sex			
Male		1.00	
Female		3.56 (3.50–3.61)	0.000
Age		1.016 (1.015–1.016)	0.000
High LDL			
Deprivation groups (most deprived)	125 948		
Group 1	4558	1.00	
Group 2	9996	1.16 (1.08–1.25)	0.000
Group 3	22 162	1.20 (1.12–1.29)	0.000

Group 4	28 971	1.25 (1.16–1.34)	0.000
Group 5 (least deprived)	60 261	1.29 (1.21–1.38)	0.000
Sex			
Male		1.00	
Female		1.37 (1.34–1.41)	0.000
Age		0.992 (0.992–0.993)	0.000

HDL=high-density lipoprotein. LDL=low-density lipoprotein.

8.3.5 Comparison between the Nuffield Health dataset and Hampshire Health Record

From previous study in Chapter 5, evidence from Nuffield Health showed that greater adiposity was found in people from more deprived groups estimated by all three measures: BMI, waist circumference, and waist-to-hip ratio. Previous findings also showed that the likelihood of having high blood pressure, however, was lower in the most deprived area than in the least deprived area. The likelihood of having low HDL was similar between groups, but the likelihood of having high total cholesterol and LDL was significantly lower in more deprived groups.

The odds ratios can differ significantly between the two datasets for individual cardiovascular risk factors and within different deprivation groups, mostly due to sample size—the dataset from Hampshire Health Record is at least ten times larger than that for Nuffield Health (and to a maximum of up to 100 times). Therefore, the following tables of odds ratios were compared in terms of value of odds ratios.

Table 8.5 shows the comparison of odds ratios for socioeconomic deprivation in relation to BMI and waist circumference after adjusting for age and sex between datasets from Nuffield Health and Hampshire Health Record. Compared with the least deprived groups, other groups in model 2 have higher a likelihood of being obese than do those in model 1 in relation to BMI and waist circumference. However, in multivariate models, females in model 1 were less likely to be obese but in model 2 were more likely to be obese than were males (odds ratio 0.71, 95% CI 0.67–0.74, $p<0.001$; and odds ratio 1.16, 95% CI 1.15–1.18, $p<0.001$). Females in model 1 and model 2 were

more likely to be centrally obese than were males (odds ratio 1.37, 95% CI 1.31–1.42, $p<0.001$; and odds ratio 1.88, 95% CI 1.79–1.96, $p<0.001$).

Table 8.5: Comparison of anthropometric characteristics (BMI and waist circumference) between private dataset and public dataset adjusted for age, sex, and deprivation (odds ratio and 95% CI)

Risk factors	Model 1*		Model 2#	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
BMI (obese)				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	0.000
Group 2	1.02 (0.95–1.10)	0.581	1.14 (1.12–1.16)	0.000
Group 3	1.04 (0.96–1.12)	0.335	1.31 (1.29–1.34)	0.000
Group 4	1.13 (1.05–1.22)	0.001	1.56 (1.53–1.59)	0.000
Group 5 (most deprived)	1.16 (1.07–1.25)	0.000	1.67 (1.62–1.71)	0.000
Sex				
Male	1.00		1.00	
Female	0.71 (0.67–0.74)	0.000	1.16 (1.15–1.18)	0.000
Age	1.024 (1.022–1.026)	0.000	1.027 (1.026–1.027)	0.000
Waist circumference (obese)				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	
Group 2	1.07 (1.00–1.15)	0.063	1.09 (1.03–1.16)	0.006
Group 3	1.14 (1.06–1.22)	0.000	1.20 (1.12–1.29)	0.000
Group 4	1.14 (1.06–1.22)	0.000	1.35 (1.26–1.45)	0.000
Group 5 (most deprived)	1.14 (1.06–1.22)	0.001	1.57 (1.45–1.71)	0.000
Sex				
Male	1.00		1.00	
Female	1.37 (1.31–1.42)	0.000	1.88 (1.79–1.96)	0.000
Age	1.038 (1.036–1.040)	0.000	1.023 (1.022–1.025)	0.000

BMI=body-mass index. * Model 1 – dataset from Nuffield Health (Chapter 5), adjusted for age, sex, and deprivation. # Model 2 – dataset from Hampshire Health Record, adjusted for age, sex, and deprivation.

Table 8.6 shows the odds for hypertension according to level of deprivation after adjusting for age and sex between datasets from Nuffield Health and Hampshire Health Record. Compared with the least deprived groups, other groups in model 2 had greater likelihood of having elevated systolic and diastolic blood pressure than did those in model 1. Adjusted odds ratio for high diastolic blood pressure was statistically highest in participants from group 3 (odds ratio 1.05, 95% CI 1.03–1.07, $p<0.001$), group 4 (odds ratio 1.03, 95% CI 1.01–1.06, $p=0.009$), and group 5 (odds ratio 1.05, 95% CI 1.02–1.09, $p=0.002$; *vs* odds ratio 0.86, 95% CI 0.78–0.94, $p=0.002$, for group 5 in model 1). Adjusted odds ratios for high systolic blood pressure was significant higher in participants from group 3 (odds ratio 1.04, 95% CI 1.02–1.05, $p<0.001$) and group 4 (odds ratio 1.05, 95% CI 1.04–1.07, $p<0.001$). In multivariate models, females in model 1 were less likely to have elevated diastolic and systolic blood pressure than were males (odds ratio 0.40, 95% CI 0.37–0.44, $p<0.001$ and odds ratio 0.54, 95% CI 0.51–0.58, $p<0.001$), but in model 2 were more likely to have elevated diastolic and systolic blood pressure than were males (odds ratio 1.62, 95% CI 1.59–1.64, $p<0.001$ and odds ratio 1.29, 95% CI 1.28–1.30, $p<0.001$).

Table 8.6: Comparison of blood pressure (systolic and diastolic) between private dataset and public dataset adjusted for age, sex, and deprivation (odds ratio and 95% CI)

Risk factors	Model 1*		Model 2 [#]	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
High diastolic blood pressure				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	
Group 2	0.95 (0.87–1.04)	0.251	1.00 (0.98–1.02)	0.979
Group 3	1.02 (0.94–1.12)	0.603	1.05 (1.03–1.07)	0.000
Group 4	0.93 (0.85–1.02)	0.131	1.03 (1.01–1.06)	0.009
Group 5 (most deprived)	0.86 (0.78–0.94)	0.002	1.05 (1.02–1.09)	0.002
Sex				
Male	1.00		1.00	
Female	0.40 (0.37–0.43)	0.000	1.62 (1.59–1.64)	0.000
Age	1.039 (1.037–1.042)	0.000	1.014 (1.014–1.015)	0.000
High systolic blood Pressure				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	
Group 2	0.96 (0.88–1.05)	0.363	1.00 (0.98–1.01)	0.422
Group 3	0.99 (0.91–1.08)	0.776	1.04 (1.02–1.05)	0.000
Group 4	1.01 (0.92–1.10)	0.875	1.05 (1.04–1.07)	0.000
Group 5 (most deprived)	0.92 (0.84–1.01)	0.078	1.01 (0.99–1.03)	0.275
Sex				
Male	1.00		1.00	
Female	0.54 (0.51–0.58)	0.000	1.29 (1.28–1.30)	0.000
Age	1.073 (1.071–1.076)	0.000	1.051 (1.051–1.051)	0.000

* Model 1 – dataset from Nuffield Health (Chapter 5), adjusted for age, sex, and deprivation. [#] Model 2 – dataset from Hampshire Health Record, adjusted for age, sex, and deprivation.

Table 8.7 shows the odds ratios for raised total and LDL cholesterol or low HDL cholesterol according to deprivation after adjusting for age and sex between datasets from Nuffield Health and Hampshire Health Record. Compared with the least deprived groups, all other groups in model 1 generally had a greater likelihood of age-adjusted and sex-adjusted raised total cholesterol and LDL cholesterol and low HDL cholesterol than did those in model 2. In multivariate models, in model 1, females were less likely to have raised total cholesterol and LDL (odds ratio 0.69, 95% CI 0.67–0.72, $p<0.001$; and odds ratio 0.49, 95% CI 0.47–0.51, $p<0.001$) and low HDL (odds ratio 0.17, 95% CI 0.16–0.19, $p<0.001$) than were males; but in model 2, females were more likely to have raised total cholesterol and LDL (odds ratio 1.68, 95% CI 1.67–1.69, $p<0.001$; and odds ratio 1.37, 95% CI 1.34–1.41, $p<0.001$) and low HDL (odds ratio 3.56, 95% CI 3.50–3.61, $p<0.001$).

Table 8.7: Comparison of plasma cholesterol (total cholesterol, HDL, and LDL) between private dataset and public dataset adjusted for age, sex, and deprivation (odds ratio and 95% CI)

Risk factors	Model 1*		Model 2 [#]	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
High total cholesterol				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	
Group 2	0.95 (0.89–1.01)	0.075	0.95 (0.94–0.96)	0.000
Group 3	0.94 (0.88–0.999)	0.046	0.82 (0.81–0.83)	0.000
Group 4	0.91 (0.85–0.96)	0.002	0.74 (0.73–0.75)	0.000
Group 5 (most deprived)	0.82 (0.77–0.88)	0.000	0.68 (0.67–0.70)	0.000
Sex				
Male	1.00		1.00	
Female	0.69 (0.67–0.72)	0.000	1.68 (1.67–1.69)	0.000
Age	1.047 (1.045–1.049)	0.000	0.993 (0.992–0.993)	0.000
Low HDL				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	
Group 2	0.97 (0.89–1.07)	0.580	0.83 (0.82–0.85)	0.000
Group 3	1.06 (0.96–1.16)	0.271	0.67 (0.65–0.68)	0.000
Group 4	0.98 (0.89–1.08)	0.676	0.54 (0.53–0.55)	0.000
Group 5 (most deprived)	0.95 (0.86–1.06)	0.365	0.43 (0.42–0.44)	0.000
Sex				
Male	1.00		1.00	
Female	0.17 (0.16–0.19)	0.000	3.56 (3.50–3.61)	0.000
Age	0.996 (0.993–0.999)	0.006	1.016 (1.015–1.016)	0.000
High LDL				
Deprivation groups				
Group 1 (least deprived)	1.00		1.00	
Group 2	1.01 (0.96–1.08)	0.653	0.96 (0.94–0.99)	0.012
Group 3	1.02 (0.96–1.08)	0.596	0.93 (0.90–0.96)	0.000
Group 4	0.92 (0.86–0.97)	0.005	0.90 (0.86–0.94)	0.000

Group 5 (most deprived)	0·81 (0·76–0·86)	0·000	0·77 (0·72–0·83)	0·000
Sex				
Male	1·00		1·00	
Female	0·49 (0·47–0·51)	0·000	1·37 (1·34–1·41)	0·000
Age	1·038 (1·036–1·040)	0·000	0·992 (0·992–0·993)	0·000

HDL=high-density lipoprotein. LDL=low-density lipoprotein. * Model 1 – dataset from Nuffield Health (Chapter 5), adjusted for age, sex, and deprivation. # Model 2 – dataset from Hampshire Health Record, adjusted for age, sex, and deprivation.

8.4 DISCUSSION

8.4.1 Overall findings of this study

This is the first study to compare participants both from a private medical insurance scheme and the public-funded NHS, and provides a unique opportunity to note the outcomes from these comparable groups. In some published literature, risk factors were usually clustered; those findings are contrasting to my research, which showed that greater adiposity was found in people from more deprived groups in data from both Hampshire Health Record and Nuffield Health estimated by two measures: BMI and waist circumference. Findings also showed that the likelihood of having high blood pressure, however, was lower in the two most deprived areas than the other least deprived area. The likelihood of having high total cholesterol and LDL, and low HDL, was significantly higher in the least deprived groups.

Compared with data from Nuffield Health, adiposity (BMI and waist circumference), blood pressure (systolic and diastolic), and total cholesterol shared the same trend with Hampshire Health Record data, and the likelihood of having high LDL and lower HDL were lower in two more deprived groups between two datasets.

8.4.2 Adiposity

Current NICE guidance (2006) suggests that assessment of the health risk associated with overweight and obesity should be based on both BMI and waist circumference. The findings of the current study agree with those from existing studies showing that people in the most deprived areas are more likely to be obese (measured by BMI). Using professional classification, Emberson *et al.* (2004) found that BMI was higher in manual than non-manual UK workers. Puslaw (2008) found higher BMI values with decreasing professional occupation. Stafford and colleagues (2010) found that residence in a more deprived neighbourhood contributed to a higher initial BMI when the study started. There was also a note that in this longitudinal, multilevel Whitehall II study of 13 years follow-up using Townsend index of multiple deprivation at census-ward level, participants from the most-deprived neighbourhoods experienced relatively greater weight gain over time, an increase of 1.5 kg/m² in men and 1.4 kg/m² in women.

A similar pattern has been found in other developed countries. Wang *et al.* (2007) gathered five cross-sectional surveys conducted by the Stanford Heart Disease Prevention Programme between 1979 and 1990 and found that participants from neighbourhoods with low socioeconomic status had a higher mean BMI than did those from neighbourhoods with high socioeconomic status, after adjusting for age, sex, ethnicity, individual-level socioeconomic status, smoking, physical activity, and nutrition knowledge. Similar findings were noted in the GLOBE study (van Lenthe and Mackenbach 2002), with odds ratios of high BMI increasing significantly with increasing neighbourhood deprivation, after adjusting for sex. Dragano *et al.* (2005) found that people with the least education were twice as likely to be obese than were the most educated people in the Czech Republic. This ratio was 1.6 in Germany. A Dutch study conducted by Han *et al.* (1998) suggested that large waist circumference was significantly associated with unemployment and lower educational level.

However, findings from the current research are inconsistent with findings from some developed countries, but similar to most developing countries. The Puerto Rico Heart Health Programme is an epidemiological study of coronary heart disease conducted in Puerto Rican men aged 45–64 years. In this study, Sorlie and Garcia-Palmieri (1990) reported that urban men with more

education are more likely to be obese. Gregory and colleagues (2007) found that the prevalence of overweight status measured by BMI was highest among Guatemalan urban men than agricultural-rural and non-agricultural rural men by using residence or occupation as a classification of socioeconomic status.

A few studies have examined the contribution of area-based socioeconomic deprivation characteristics to the distribution of health-related behaviour. Ellaway and colleagues (1996, 1997) investigated health-related behaviour and physical measurements in relation to social characteristics of area of residence in Glasgow. They found that poorer areas contained people who were less likely to consume (and had less access to) healthy food, less likely to participate in sport, and more likely to be smokers, be shorter, and have higher BMI and greater waist-to-hip ratio. According to the report “Food Matters” (Cabinet Office 2008), more than 70 000 lives could be saved each year in the UK with a healthy diet. In 2009, the UK Food Standards Agency suggested that about 150 000 deaths from cardiovascular disease annually were due to poor dietary health (Food Standards Agency 2009). Some studies have found that there are more fast-food outlets per capita and fewer health food stores per capita in the most deprived compared with least deprived areas, although the evidence is not consistent across all countries (Cummins and Macintyre 2002; Li *et al.* 2008; Li *et al.* 2009; Li *et al.* 2009; Mehta *et al.* 2008; Mujahid *et al.* 2008; Rundle *et al.* 2009).

In 2009, the Cardio and Vascular Coalition published “Destination 2020”—the voluntary sector’s plan for cardiac and vascular health in England (Cardio and Vascular Coalition 2009). Government policy in many areas influences cardiovascular disease. The “Choosing Health” white paper (DH 2004) set priorities for action on nutrition, physical activity, obesity, and tobacco control, including the provision of NHS Stop Smoking Services. To tackle the substantial burden of ill health from cardiovascular disease and associated risk factors, the UK Royal College of Physicians recommended establishing a subspecialty of obesity medicine for physicians. The terms “bariatric medicine” and “bariatric physicians” were also proposed (Royal College of Physicians 2013). Also, for the government’s consideration, the next stage of policy development should focus on effective local and regional, population-level programmes to prevent cardiovascular disease,

obesity, and hypertension. There is a need to focus on interventions targeting specific cardiovascular risk factors, such as salt intake, saturated fats, and trans fatty acids. Policies to promote physical activity and increase the consumption of fruit and vegetables should be implemented, with a special focus on socially disadvantaged groups.

8.4.3 Blood pressure

Given the confirmatory nature of the present data regarding the association between obesity and deprivation, it was expected that the consequent risk factor, blood pressure, would be elevated in a similar graded manner with deprivation. The data are not all, but in part, supportive of this hypothesis, with systolic and diastolic blood pressure both lower in participants from the two least deprived quintiles.

Our data are in agreement with much of the previous work conducted in developed countries. In a review of published literature to assess the association between socioeconomic status and blood pressure, high mean blood pressure or prevalence of hypertension was associated with low socioeconomic status in almost all studies from North America and most from Europe, regardless of the measure of socioeconomic status used (Colham *et al.* 1998). In the Whitehall study of London-based civil servants, mean blood pressure and prevalence of hypertension were higher among men in the lower grades of employment (Marmot 1985). Hart and colleagues (2000) also found that adults from the most deprived areas were at a higher risk of high blood pressure than were those in the least deprived areas. In a study from developing countries, Cubbin *et al.* (2001) noted that blood pressure was higher in the most deprived areas than in the least deprived areas among African women.

This association is in contrast to the findings in most developing countries. Fernald and Adler (2008) conducted a house-to-house cross-sectional survey in women aged 18–65 years in Mexico. They found that two indicators of socioeconomic deprivation—educational attainment and working outside the home—showed an inverse association with systolic blood pressure. Similar findings have also been found in a multicentre collaborative study of risk factors for cardiovascular

disease in the International Clinical Epidemiology Network (INCLIN). Nogueira *et al.* (1994) examined the relationship between risk factors for cardiovascular disease and socioeconomic variables in 12 centres in seven countries—three in Thailand, two each in China, Chile, and Brazil, and one each in the Philippines, Indonesia, and Colombia. They investigated approximately 200 men aged 35–65 years drawn at random from a population within their locality and found that among the five Latin America countries, three showed a negative association between socioeconomic status and systolic blood pressure, and others showed no association. A study of hypertension in an urban working population in Ghana showed a lower prevalence of hypertension in participants of lower socioeconomic status and the highest prevalence in those of the highest socioeconomic status (Addo 2009). There were suggestions of a negative association between the level of education and hypertension after adjusting for the other measures of socioeconomic status.

In the UK, nearly complete registration with the NHS provides a potential vehicle for systematic identification of patients with hypertension, applying best practice guidelines and ensuring regular review. The NHS Health Check programme (NHS Choices 2009), launched in 2009, is aimed at the population aged 40–74 years. It is intended to progressively reduce the number of undiagnosed individuals with hypertension and other cardiovascular risk factors in the next five years. The options for enhanced hypertension control are cost effective and well described in the NICE guidance (2011). An analysis done by Murray and colleagues (2013) also emphasises that there could be important opportunities for primary prevention through reduced alcohol and salt intake, reduced BMI, increased physical activity, and increased intake of specific dietary components, such as fruit. Improved early detection and long-term management of high blood pressure could be one clear route to accelerate progress for the leading causes of avoidable cardiovascular mortality. Data from examination surveys in England and Scotland confirm that existing approaches have not adequately identified and treated hypertension (Falaschetti *et al* 2009; Mohan and Campbell 2009; The Scottish Government 2010). In Scotland in 2009, one in five men and one in seven women younger than 75 years had untreated hypertension (The Scottish Government 2010). Although there is evidence of some improvements in hypertension control in England (Falaschetti *et al* 2009; Mohan and Campbell 2009), only a third of men with hypertension were controlled in 2006 (Falaschetti *et al* 2009). This represents a pool of potentially preventable

mortality and morbidity. Changes to the wider determinants of health have often been as a consequence of public health policy. Preventive services are unlikely to tackle these wider determinants unless supported by national policies and systems (Capewell and O'Flaherty 2008).

8.4.4 Plasma cholesterol

Like blood pressure, plasma cholesterol is a risk factor often associated with increased adiposity. In this study, participants from the least deprived areas had less favourable serum lipids compared with individuals from the most deprived areas. Elevated total cholesterol and LDL cholesterol, as well as low HDL cholesterol measures, were significantly higher in the most deprived groups.

Smith and colleague (1998) in the Renfrew and Paisley study reported that plasma cholesterol was lower for men and women in manual social class groups than for those in non-manual workers. This finding is in line with several studies in the UK (Pocock *et al.* 1987; Smith *et al.* 1990). Although from developing countries, several studies including from China have also confirmed this finding (Bunker *et al.* 1996; Pereira *et al.* 1998; Siegrist *et al.* 1990; Sorlie *et al.* 1990; Tian *et al.* 1995; Yu *et al.* 2001).

Our data are in contrast to those of a study of 2682 Finnish men in the Kuopio ischaemic heart disease risk factor study (KIHD). Using educational levels as a measure of socioeconomic status, Lynch *et al.* (2006) found that total cholesterol was significantly higher for those who attended primary school only than for those who were high school graduates in Finland. In the Puerto Rico Heart Programme, Sorlie and Garcia-Palmieri (1990) found that mean values for serum cholesterol increased steadily with educational level, indicating a cholesterol level that was approximately 29 mg/dL (0.75 mmol/L) lower for those with no education compared with those at the highest level in urban areas.

In terms of low HDL cholesterol, our findings agree with reports by Winkleby and colleagues (1992) that low HDL was found more often in the highest socioeconomic groups. Lynch *et al.* (2006) found that HDL was higher in people who had primary education only than for those who

were high school graduates. Pereira *et al.* (1998) also conducted a study in a population aged 25–74 years in Mauritius. Using occupation as a measure of socioeconomic status, they found that HDL was higher in unskilled workers than in professional or skilled workers. They also noted that females were five times less likely than males to have lower HDL. In two Chinese studies, however, the authors found that men in lower socioeconomic status were significantly more likely to have low HDL compared with men of higher socioeconomic status (Siegrist *et al.* 1990; Yu *et al.* 2001).

LDL cholesterol had a similar pattern to that for total cholesterol. Our findings agree with those of several Chinese studies (Siegrist *et al.* 1990; Tian *et al.* 1995; Yu *et al.* 2001), which found that men of higher socioeconomic status had significantly higher LDL compared with men in low socioeconomic status. Pereira *et al.* (1998) also reported that LDL was lower in unskilled workers than in professional or skilled workers. By contrast, Larranaga *et al.* (2005) found that adults of lower socioeconomic status attending primary care clinics in the Basque region of Spain had higher LDL compared with those of a higher socioeconomic status. Using educational levels as a measure of socioeconomic status, Lynch *et al.* (2006) found that LDL was significantly higher for those who attended primary school only than for those who were high school graduates.

A few studies have also reported that elevated cholesterol is associated with lower socioeconomic status due to the reduced intake of saturated fats, lower alcohol consumption, and consumption of more fruit, vegetables, and whole grains (Briefel and Johnson 2004; Kanjilal *et al.* 2006; Marmot *et al.* 1991; McFadden *et al.* 2009; Popkin *et al.* 1996).

8.4.5 Strengths and limitations of this study

The study is one of the largest datasets on deprivation indices with this number of risk factors in the primary care setting. The south central England region spends £5.5 billion a year on the health and wellbeing of the million people in their communities, which is a relatively low funding allocation per head of population, owing to the fact that the region is relatively affluent compared with the national average. Although many more affluent areas such as Winchester and Wokingham are located in this territory, there are also some socially more deprived areas—in parts of Portsmouth, Southampton, and Slough. This region received less than the average of the national funding allocation. The relative wealth of the population included in the region is not matched by lower demands on the health system and this has placed local commissioners in a difficult financial situation historically. Local residents are typically very informed and influential and demand the very best from the NHS. However, because South Central PCTs receive the lowest per capita allocation in the NHS, as finances tighten, a significant funding gap will need to be addressed and the health system will need to be re-sized to meet the challenge and identify the biggest opportunities for improvement in quality, outcomes, and productivity.

This research also confirmed the previous findings from Chapter 5 that the two datasets are comparable. The number of people covered by private medical insurance in the UK rose to over 6 million in 2008, according to figures from the Association of British Insurers (2009), and an increasing number of those included in our dataset will be those employed in all sectors of the workforce from manual to management. Our results might not only be generalisable to other commercially insured populations, but also to some affluent areas in the UK. Although many studies have assessed the association between socioeconomic status and cardiovascular risk factors, those studies were on the basis of a much smaller sample size than was used in this study, so the results are not as reliable and generalisable as those of this study.

When using area-based indicators of socioeconomic position, two forms of bias could be introduced (Davey *et al.* 1996; Geronimus *et al.* 1996). It could be considered that the area-based measure serves as a proxy indicator of individual socioeconomic circumstances. In this instance the associations between area-based socioeconomic measures and health outcomes would be

underestimates of underlying associations between individual socioeconomic position and health, as considerable misclassification of individual socioeconomic circumstances by the area-based measure could occur. Technically, the residuals from analyses using individual-level data will be correlated with the area-based indicator (Firebaugh 1978; Geronimus *et al.* 1996). Therefore, to fully reflect the socioeconomic circumstances, it would be ideal if individual socioeconomic characteristics could be collected and used in addition to area-based measurements.

The empirical findings with respect to these questions have been variable and have depended on the context of studies and the health outcomes under examination. The contextual effects of areas, and the size of areas that determine these effects, will differ in different places and for different health outcomes, so this inconsistency in the literature is not unexpected. The particular aspects of different areas that may influence health independently of individual social class are currently under investigation.

Another limitation of this study is that the dataset does not include a history of medication. Use of lipid-lowering drugs, primarily statin therapy, is recommended for patients with clinical evidence of cardiovascular disease. However, as this is a private medical insurance company, it only has limited data resources because participants are still seeing their GPs to prescribe medication. Therefore, it is hard to know if participants' blood pressure and cholesterol level were drug controlled. Also, the present study did not measure habitual physical activity, but it may be that more deprived participants were more active than those in the least deprived groups. Socioeconomic groups, but not postcode, were provided by datasets from Hampshire Health Record. Therefore, a direct comparison of socioeconomic status is not able to be compared with the general population in terms of IMD rank, as well as Nuffield quintiles. In the NHS data, the IMD "quintiles" were of very different size, because datasets of variables are provided in individual files. Therefore, it is possible that the #1 patient in BMI file is not the same patient in the blood pressure file. Therefore, the NHS datasets calculated the estimates of different variables, although from the population living in the same region, not equally-sized quintiles. This should also be noted as a limitation of this study.

The English Indices of Deprivation 2007 have been used not only by health researchers, but also by government for the past 10 years to identify and target areas of concentrated deprivation—important in directing significant levels of government funding, both for regeneration and other programmes. It is argued that the English Indices of Deprivation might not be an adequate tool for understanding and addressing the challenges of rural deprivation, mainly because it fails to adequately detect the many deprived individuals and households that live outside of the most deprived areas, and rural deprivation has some particular characteristics that are not picked up by the indicators and the methodology. In addition, previous research (Smith *et al.* 1998) has called for a range of characteristics, including environmental effects, housing conditions, social disorganisation, transport, insecurity about personal safety, the availability of retail and leisure facilities, socially determined health-related behaviours, and access to health care. These should be considered in the area-based measurement, which has been included in the English Indices of Deprivation 2007.

8.5 CONCLUSION

In summary, these findings show that socioeconomic deprivation is a strong and independent predictor, and that it has an effect in the development of cardiovascular risk factors in people living in the south England region. Although the two datasets are comparable, people living in the south England region were more likely to develop obesity and hypertension, but less likely to have elevated cholesterol and LDL, as well as low HDL, compared with those from Nuffield Health. The south England region has a higher proportion of ageing population, and the area is more affluent than the national average, which could explain the above findings. Therefore, regional preventive policy should focus on these higher prevalent cardiovascular risk factors, especially for the high-risk population in the region. Simple diet policy initiatives, such as reduction of salt intake, and lifestyle change in the region could achieve corresponding decreases in cardiovascular deaths. Extra care is needed when designing appropriate exercise programmes for different age groups. For example, falls and related fractures are a major health problem for elderly. Exercise can modify intrinsic fall risk factors and thus prevent falls in this age group. It is important to design exercise programme for appropriate age groups.

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CHAPTER 9 SUMMARY AND CONCLUSIONS

9.1 SUMMARY

The final chapter of this thesis presents an opportunity to review the whole thesis and to emphasise the main conclusions. Instead of summarising in the conventional prose style, this summary follows the model used in the *British Medical Journal* and others. It is presented in the form of brief bullet points relating to what is known on the topic and what the current research adds to the topic. This will provide a clear and concise summary of the work undertaken.

CHAPTER 3: SOCIOECONOMIC STATUS, CARDIOVASCULAR DISEASE, AND ASSOCIATED RISK FACTORS—A LITERATURE REVIEW

WHAT IS ALREADY KNOWN

- The burden of cardiovascular disease is large, costly and increasing, both in the UK and worldwide. According to the World Health Organization (WHO), 17·3 million people died from cardiovascular disease worldwide in 2008 and more than 23 million people will die annually from cardiovascular disease by 2030. Yet, 80–90% of premature cardiovascular disease is preventable.
- Tobacco use, an unhealthy diet, and physical inactivity increase the risk of heart attacks and strokes.
- The health effect of physical activity goes well beyond preventing overweight and obesity; they can also benefit physical and mental wellbeing—heart disease and type 2 diabetes could be reduced up to 50% and hypertension significantly reduced.
- In the UK, the prevalence of cardiovascular disease is high—over 3 million people currently suffer from this disorder.

- The most important modifiable factors contributing to cardiovascular disease are: smoking, elevated cholesterol, elevated blood pressure, diabetes, obesity, and socioeconomic deprivation.
- A better understanding of the most effective interventions for reducing this large and costly disease burden is vital in order to inform strategies to combat cardiovascular disease in the UK and elsewhere.

WHAT THIS CHAPTER ADDS

- Research focusing on cardiovascular health in ageing populations, different socioeconomic groups, and various ethnic groups, especially south Asian people in the UK, is needed.
- Given that very little research has been undertaken in the growing population who pay for private medical insurance, priority should be given to this emerging area.
- Research data are scarce for serum lipids, specifically for low-density lipoprotein (LDL) in the UK population, so more research is needed.

CHAPTER 4: PREVALENCE OF MODIFIABLE CARDIOVASCULAR RISK

FACTORS IN PEOPLE ATTENDING PRIVATE MEDICAL SCREENING

WHAT IS ALREADY KNOWN

- Cardiovascular mortality, incidence, and prevalence rates increase steeply with age, approximately doubling with each decade. Cardiovascular disease is rare in people younger than 30 years, but increasingly common above the age of 60 years.
- According to the European Health Interview Survey in 2011, the highest proportions of obese women were recorded in the UK (23·9%), Malta (21·1%), Latvia (20·9%), and Estonia (20·5% in 2006/07), and of men in Malta (24·7%), the UK (22·1%), Hungary (21·4%), and the Czech Republic (18·4%).
- It has been estimated that at present at least 1·1 billion adults are overweight, including 312 million who are obese.
- The UK's Observatory estimates that the number of people with high blood pressure increased by 2·7% from 332 767 in 2004–05 to more than 12 million in 2007–08.
- In 2008, the global prevalence of raised total cholesterol among adults was 39% (37% in men and 40% in women).

WHAT THIS CHAPTER ADDS

- In the analysis from the dataset provided by Nuffield Health, men and women who were aged 35–44 years (group 3) and 45–54 years (group 4) had the highest prevalence of obesity and overweight compared with other age groups. By comparison with the Health Survey for England 2006, our data showed that men in Nuffield Health were more likely to be overweight, but less likely to be obese, and

women were less likely to be overweight, but more likely to be obese, when using body-mass index (BMI) as a measurement for overweight and obesity.

- Men and women aged 45–54 years (group 4) had the highest prevalence of high systolic and diastolic blood pressures, which was a different pattern to that shown by the Health Survey for England 2006—the prevalence rate of hypertension was going up with increasing age both in men and women. Men aged between 16 and 24 years had the lowest prevalence rate (6%), and aged over 75 years had the highest prevalence rate (75%). Women aged between 16 and 24 years had the lowest prevalence rate (1%), and aged over 75 had the highest prevalence rate (77%). Women were likely to have lower prevalence than in men at ages less than 65 years, but higher prevalence older than 65 years.
- Men and women aged 45–54 years (group 4) had the highest prevalence of high total cholesterol and LDL. Men in group 4 had the highest prevalence of low high-density lipoprotein (HDL), while women aged 35–44 years (group 3) had the highest prevalence of low HDL. In the Health Survey for England 2006, in men, the prevalence of high total cholesterol went up with increasing age up to 55 years, but decreased at ages 55 years and over. The pattern was slightly different in women, in whom prevalence went up with increasing age up to 65 years, and decreased at age 65 years and over.
- Our findings showed some similarity with existing studies, especially in the UK population. Our dataset is one of the largest UK datasets especially in a commercial setting. More research is needed in the private sector because of the current UK NHS reform.

**CHAPTER 5: SOCIOECONOMIC STATUS AND MODIFIABLE
CARDIOVASCULAR RISK FACTORS IN PEOPLE ATTENDING PRIVATE
MEDICAL SCREENING: AN OBSERVATIONAL STUDY**

WHAT IS ALREADY KNOWN

- Socioeconomic factors play an important part in cardiovascular disease, with mortality rates almost twice as high in deprived than in affluent areas.
- Around a third of adults have three or more risk factors such as raised cholesterol, diabetes, or being overweight, which increase their chance of poor health. This increases to around two-fifths of adults in the most deprived areas.
- Deprivation indices are easier to apply in clinical practice than are most other measurements of socioeconomic status, and have consequently become popular among public health researchers.

WHAT THIS CHAPTER ADDS

- Some published literature, in which risk factors were usually clustered, shows contrasting or paradoxical findings to my research—greater adiposity was found in people from more deprived groups estimated by all three measures: BMI, waist circumference, and waist-to-hip ratio.
- Our findings also showed that the likelihood of having high blood pressure, however, was lower in the most deprived area than in the least deprived area.
- The likelihood of having low HDL was similar between groups, but the likelihood of having high total cholesterol and LDL was significantly lower in the more deprived groups.

CHAPTER 6: REGIONAL DIFFERENCES IN MODIFIABLE CARDIOVASCULAR RISK FACTORS IN PEOPLE ATTENDING PRIVATE MEDICAL SCREENING

WHAT IS ALREADY KNOWN

- Geographical variations in cardiovascular disease and associated risk factors have been identified and reported in a range of European countries on the basis of both prevalence and incidence.
- Death rates and prevalence of coronary heart disease are persistently higher in Scotland, Wales, and Northern Ireland than in southeast England. These geographical variations suggest that large improvements in UK coronary heart disease mortality are still attainable.
- The Health Survey for England is an annual health examination survey of a new, nationally representative sample of the English population living in private households. It provides representative data for a broad range of health topics.
- The Health Survey for England 2006 report focused on cardiovascular disease and associated risk factors, which covered health status risk factors including total cholesterol, HDL cholesterol, blood pressure, diabetes, and anthropometric measurements such as BMI and waist circumference.
- Modifiable cardiovascular risk factors vary in prevalence across the UK. In England, this is exemplified at a regional level by a north–south gradient in prevalence and health outcomes, with higher prevalence in the north.
- Many reasons have been proposed for regional variations in cardiovascular diseases—differences between populations in cardiovascular risk factors such as smoking, hypertension, hyperlipidaemia, diabetes, or overweight as well as socioeconomic

factors, lifestyle variables such as diet, alcohol use, physical activity, medical care, genetic factors, and environmental conditions.

WHAT THIS CHAPTER ADDS

- This is one of the first studies to show regional differences across the UK with such a high number of risk factors and other variables in a primary care setting, but was restricted to participants in a private health-care company.
- Overall, the prevalence of various modifiable cardiovascular risk factors was higher in Health Survey for England 2006 data than in the Nuffield Health dataset, both in men and women across all regions in England.
- This study provided a unique opportunity to study how geographical regions have an effect on modifiable cardiovascular risk factors in a large UK population from a private health-care company.
- In men, the prevalence of being overweight, having a raised waist circumference, and having raised total cholesterol were higher in Nuffield Health data than in Health Survey for England data. Men in London were generally healthier than were men from other regions in England. Differences in prevalence of several risk factors were wider between regions, such as raised waist circumference (up to two times), lower HDL (over three times), and hypertension (about two times).
- In women, the prevalence of obesity, raised waist circumference, and hypertension were much lower in the Nuffield Health data than in Health Survey for England 2006 data. Only the difference in prevalence of hypertension was wider between regions (more than two times).

- Our findings showed that both men and women in south England were less likely to be obese than were those in other regions in England.
- Participants in the southeast had the highest risk of being hypertensive, but those from York and the Humber had the lowest risk, compared with those from other regions in England. Men could have more than twice as great a risk compared with women of being hypertensive.
- In term of plasma cholesterol, the distribution varied among regions—participants in the northeast had the highest risk of having elevated total cholesterol, but those in the northwest had the lowest risk; both men and women in the Midlands were less likely to have a lower HDL than were those in other regions of England; participants in the north of England were less likely to have lower LDL than were those in other regions of England.
- The North-South effect (or Scottish effect) on prevalence of cardiovascular disease and associated risk factors was not seen in this affluent population. We could speculate that this effect might be generalisable to the same population in other European countries.

CHAPTER 7: COMPARISON BETWEEN PREVALENCE OF MODIFIABLE CARDIOVASCULAR RISK FACTORS IN PEOPLE ATTENDING PRIVATE MEDICAL SCREENING AND NATIONAL HEALTH SERVICES FROM SOUTH ENGLAND IN DIFFERENT AGE GROUPS

WHAT IS ALREADY KNOWN

- The WHO toolkit estimates that the top ten risk factors for early death and disability in the UK are, in order of impact—tobacco use, harmful alcohol consumption, high

blood pressure, high blood cholesterol, overweight and obesity, physical inactivity, illicit drug use, low fruit and vegetable intake, occupational risks, and poor sexual health.

- Approximately 25% of those aged 16 years and over report one lifestyle risk factor, 33% two risk factors, 23% three risk factors, and 12% four or more risk factors. Only 7% of adults have no risk factors.
- Although cardiovascular mortality rates have halved in the past two decades, morbidity, particularly in older age groups, appears to be very persistent.
- Death rates from coronary heart disease continue to fall in people older than 55 years, but have recently been falling more slowly in younger individuals and may be rising in the youngest age groups.
- The percentage of the population with high blood pressure increases progressively with age. In 2008–10, 4·1% of 14–24 year olds had high blood pressure, compared with 25·9% of 45–54 year olds and 72·8% of those aged 75 years and over.
- Cholesterol levels have been falling over time, largely as a result of increased prescription of statins and other lipid-lowering drugs: between 1994 and 2006, the percentage of men with raised cholesterol fell from 74% to 57% and among women from 77% to 61%.
- Dietary control and physical activity are effective in reducing obesity and overweight at an individual level, although creating environments that promote and enable healthy eating and active lives requires action across industry, local government, and the NHS.

WHAT THIS CHAPTER ADDS

- The south England region is a more affluent region in the UK. Nuffield Health is a private health-care company, and people attending this company are more likely to be of higher socioeconomic status. Therefore, it is possible to compare the clinical outcomes of people who attended Nuffield Health with those located in the south central England region.
- Overall, in the south England region, about one in two people is overweight or obese. Individuals tend to have higher systolic blood pressure, but lower diastolic blood pressure. About 60% and 45% of participants have elevated total cholesterol and LDL, respectively, and 16% of participants have lower HDL.
- Individuals aged between 55 and 75 years had more cardiovascular risk factors than did those younger than 55 years.
- It was hypothesised that the population from the NHS trust dataset had lower BMI than did those from Nuffield Health's dataset; however, women had a lower BMI in the Nuffield Health's dataset.

CHAPTER 8: COMPARISON OF THE EFFECT OF CARDIOVASCULAR RISK FACTORS IN DIFFERENT SOCIOECONOMIC GROUPS PROVIDED BY NUFFIELD HEALTH AND HAMPSHIRE HEALTH RECORD

WHAT IS ALREADY KNOWN

- Evidence showed that structural policy and legislative changes at regional, national, and international levels could significantly prevent cardiovascular risk factors.

- A model study estimated that a 10% reduction in blood pressure, cholesterol, and prevalence of smoking would save 9125 lives per million of the population over 10 years; by contrast, treating 40% of high-risk individuals with a polypill—containing a statin, three half-dose antihypertensives, and aspirin—would save about 3720 lives per million, even assuming complete, long-term adherence.
- Reducing the risks—such as quitting smoking or changes to the diet—could reduce cholesterol or blood pressure, which could therefore lead to a reduction of the development of cardiovascular disease. Some population-based prevention programmes have been accompanied by a substantial reduction in the rate of cardiovascular disease mortality.
- The prevalence of obesity and overweight continues to rise in the UK. The disease burden associated with overweight and obesity is considerable: the cost to the UK's NHS has been estimated to be £3.2 billion per year.
- A particularly important socioeconomic factor linked to obesity is education, with some extent of an association shown between higher education and a lower likelihood of obesity. This might help to resolve the obesity epidemic by increasing general school education and supporting the delivery of health and lifestyle education, or both.

WHAT THIS CHAPTER ADDS

- This is the first study to compare participants both from a private health-care company and the public-funded NHS. It provides a unique opportunity to open the research arena and note the outcomes from these comparable groups.

- In some published literature, in which risk factors were usually clustered, there are contrasting or paradoxical findings to those of my research—greater adiposity was found in people from more deprived groups estimated by two measures: BMI and waist circumference.
- Findings also showed that the likelihood of having high blood pressure, however, was lower in the two most deprived areas than in the other least deprived area. The likelihood of having high total cholesterol and LDL and low HDL were significantly higher in the least deprived groups.
- By comparison with data from Nuffield Health, adiposity (BMI and waist circumference), blood pressure (systolic and diastolic), and total cholesterol shared the same trend with Hampshire Health Record data, and the likelihood of having high LDL and lower HDL was lower in the two most deprived groups between the two datasets.
- Evidence-based population-wide policy interventions exist, and these interventions should now be urgently implemented to tackle persistent inequalities effectively.

9.2 RECOMMENDATIONS FOR FUTURE RESEARCH

- Individual socioeconomic characteristics should be collected and used in addition to area-based measurements to reflect socioeconomic circumstances fully. Educational level has been noted to be better associated with cardiovascular risk factors as a measurement of individual socioeconomic status.
- Smoking is the single largest cause of death, disability, preventable illness, and unnecessary health expense in the UK. It has caused approximately 17–30% of all cardiovascular deaths. It has been estimated that a lifespan is shortened by smoking by up to 10 years. About 50% of smokers die of a smoking-related illness. Therefore, it would be useful to have data for smoking from the south central England region, and compare the outcome with the data from Nuffield Health.
- Blood pressure measurement is a measure that needs considerable improvement, as it is influenced by many factors such as instruments, the researcher, subjects, and the environment where the measure is taken.
- Non-white populations, such as south Asians living in the UK—Indians, Bangladeshis, Pakistanis, and Sri Lankans—have a roughly 50% higher premature death rate from cardiovascular disease compared with those who were born and live in the UK. Also, south Asian immigrants are more likely to die prematurely from cardiovascular disease. Therefore, data for ethnicity should be collected and analysed in the future.

9.3 PUBLIC HEALTH IMPLICATIONS OF THE THESIS

On the basis of the Hampshire Health Record, the population aged 65–75 years are at a much higher risk of developing cardiovascular disease than are those aged 18–24 years. For certain cardiovascular risk factors, this could be up to 100 times higher. Between 2006 and 2020, the UK

population is expected to increase by 10% to almost 65 million, an additional 3.2 million men and 2.7 million women. The older age groups will experience much larger increases in numbers. Cardiovascular death rates are much higher in the oldest groups. Because of population ageing, the total numbers of deaths are therefore likely to increase substantially. The future continuing burden of cardiovascular disease will increasingly affect older groups and will stretch health-care systems, even in the UK and other wealthy countries.

Ethnicity and gender, especially south Asian and Chinese groups in the UK. South Asians living in the UK—Indians, Bangladeshis, Pakistanis, and Sri Lankans—have a roughly 50% higher premature death rate from cardiovascular disease compared with the white population. Mortality rates for coronary heart disease and stroke vary by ethnic group in the UK. Premature death rates from coronary heart disease for men born in the Caribbean and west Africa and for women born in Italy but living in the UK were lower than average. However, there is a higher premature death rate from coronary heart disease than average among men and women living in the UK but born in south Asia and eastern Europe. In 2003, the death rate among Bangladeshi men was 112% higher and the death rate among Pakistani women living in England was 146% higher than the average for England and Wales. Men living in England but born in Bangladesh have more than twice the average chance of suffering premature death from stroke. Women born in Jamaica and living in England were 76% more likely to die prematurely from stroke than those born in England and Wales (Harding *et al*, 2008).

The difference in the death rates between those born in south Asia and the general population increased in the 1970s and 1980s. This is because the death rate from coronary heart disease was not falling as fast in south Asian groups as it was in the rest of the population. For example, from 1971 to 1991, the mortality rate of coronary heart disease for 20–70 year olds for the whole population fell by 29% for men and 17% for women, whereas in people born in south Asia it fell by only 20% for men and 7% for women (McKeigue *et al*, 1996). Furthermore, inequalities in mortality rates between the general population and south Asians are continuing to increase (Harding *et al*. 2008).

Regional-level and national-level clinical outcome data should be collected. Action and advocacy could be an important step forward in dealing with increasing weight status. Governmental actions, such as taxation and subsidies, are favourable for public health measures for changing consumers' behaviour. Prevention at a population level requires co-ordination. In the UK, the national level is addressed by the National Heart Forum (NHF). The NHF was established in 1984 as an "active authoritative body at the national level to speak out for policies directed at the prevention of coronary heart disease" and to maximise the contributions of not-for-profit sector organisations. Since its launch, NHF has been instrumental in driving the national prevention policy agenda for coronary heart disease, developing consensus and evidence-based recommendations for action across a diverse range of issues and settings, and coordinating advocacy for their implementation. NHF's mission is to work with and through their members to contribute to the prevention of avoidable coronary heart disease and related conditions in the UK.

Regional programmes also energetically address prevention, such as Heart of Mersey (HoM). HoM was launched as a non-governmental organisation in 2003 and became a registered charity in 2005. HoM is an excellent working example of a regional health regeneration partnership. HoM aims to add value to local initiatives and programmes by working at local, regional, national, and European levels to prevent cardiovascular disease in the population through integrated, evidence-based interventions. The programme targets the major risk factors associated with achieving these aims, mainly poor diet (dietary fat, salt, and sugar), and smoking (including second-hand smoke).

9.4 GENERALISABILITY

Although the population who attended Nuffield Health were all over the UK, this study can only be generalised to the UK healthy and wealthy population and caution must be taken in comparing these data to the whole of the UK population, especially those from poorer socioeconomic backgrounds and the high-risk disease population. The south central England region is one of the most affluent populations with the least diverse ethnic minorities.

There is a great chance of bias owing to the retrospective data collection. It might be difficult to establish the correct temporal relationship between socioeconomic deprivation and cardiovascular risk factors. However, there are advantages of a retrospective design. It was easy to conduct, cheaper, faster when there are time constraints, and provided good prevalence estimates in the population. It was also possible to compare different variables (such as age and sex) and carry out subgroup analyses, and more efficient for studying disease risk factors with long induction and latent periods. When it is not statistically definitive it can help refine questions, generate hypotheses, identify potential recruits for experimental studies, complement experimental studies, and generally inform the design of other research. And often it can proceed without the participants having to be involved or affected, especially if it uses anonymised data.

Data quality is one of the common issues to ensure the robustness of secondary research. Data quality is important because accurate and timely information are needed to manage health services and improve quality of patient care; provide good information to manage health service effectiveness; prioritise and locate the health resources; and make judgements about the performance and governance in the organisation. Obtaining good-quality data is only a starting point, ultimately achieving data quality should be able to help to ensure that high-quality evidence is used to guide the allocation of health-care resources efficiently and improve the patient care.

9.5 INTEGRATED SUMMARY OF THE THESIS

This thesis has mainly focused on a cluster of cardiovascular risk factors in a large UK population whose backgrounds were relatively affluent and wealthy. From the Nuffield Health dataset, it has shown that men and women aged 45–54 years were more likely to have higher cluster of cardiovascular risk factors. Participants from the most deprived groups were less likely to have higher blood pressure, but more likely to be obese and have elevated cholesterol and LDL, than were those from the least deprived groups. Intervention strategies seem to work for high blood pressure, but for women only. No intervention strategy has shown an association between physical activity and LDL and total cholesterol ratio, as well as HDL. Little is known about the effect of physical activity on novel risk factors, such as inflammatory and haemostatic markers and glucose

metabolism, so more research in this area is urgently needed. The opportunity to analyse participants by English regions, has shown that both men and women in south England were less likely to be obese than were those in other regions in England.

The south central England region, where the Hampshire Health Record collected its data, spends £5.5 billion a year on the health and wellbeing of the million people in their communities, which is a relatively low funding allocation per head of population, because the region is relatively affluent compared with the national average. This was the first opportunity to compare participants both from a private health-care company and NHS services in more affluent areas. It provided a unique opportunity to open the research arena and note the outcomes from these comparable groups. From this comparable design, it showed that ageing is a serious problem in the south central England region: individuals aged between 55 and 75 years had more cardiovascular risk factors than those younger than 55 years. Participants were more likely to be obese, had higher systolic blood pressure, and elevated total cholesterol, and LDL cholesterol. Lower socioeconomic groups should be a target for policy makers to tackle obesity, hypertension, and elevated cholesterol, especially with limited health services and funding shortages. Evidence-based population-wide policy interventions exist, but these interventions should now be urgently implemented to tackle persistent health inequalities effectively.

Challenges remain in the area of policy evaluation. Health policy makers need to allow flexibility in programme evaluation designs to allow them to adapt to local needs, rather than requiring fixed plans prior to funding. In addition, programmes and evaluations should allow sufficient time for outcomes to be achieved. A better understanding of the most effective interventions for reducing this large and costly disease burden is vital, in order to inform strategies to combat cardiovascular disease in the UK. Approaches that change the physical and social environment (eg, smoke-free workplaces, healthier default food options, infrastructure that facilitate physical activity) mean that people are more likely to make healthier choices. Prevention of cardiovascular diseases is not necessarily costly. Many health-promotion policies (eg, bans on smoking and trans-fat use) cost government very little in public funds, and some initiatives (eg, cigarette taxes) generate revenue for government that can be used to pay for prevention programmes. Effective interventions require

support from the highest levels of government. Local government support is crucial in the implementation of the policies. Political commitment is fundamental to success in the fight against cardiovascular diseases. As New York City Mayor Michael Bloomberg has noted, “while government action is not sufficient alone, it is nevertheless absolutely essential. There are powers only governments can exercise, policies only governments can mandate and enforce, and results only governments can achieve. To halt the worldwide epidemic of non-communicable diseases, governments at all levels must make healthy solutions the default social option. That is, ultimately, government’s highest duty.”

9.6 REFERENCES

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