SOCIOECONOMIC INEQUALITIES IN CARDIOVASCULAR DISEASE IN AN AGEING POPULATION

CIP-GEGEVENS KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Rossum, Cornelia Theodora Maria van

Socioeconomic inequalities in cardiovascular disease in an ageing population / Cornelia Theodora Maria van Rossum.
Thesis Rotterdam - With ref. - With summary in Dutch
ISBN 90-9012252-4
Subject headings: mortality / cardiovascular disease / socioeconomic factors /aged / The Netherlands / Great Britain

Printed by: Ipskamp Print Partners, The Netherlands
Cover design: Sjon van Rossum

SOCIOECONOMIC INEQUALITIES IN CARDIOVASCULAR DISEASE IN AN AGEING POPULATION

Sociaal-economische verschillen in het
voorkomen van hart- en vaatziekten
op oudere leeftijd

Proefschrift

ter verkrijging van de graad van doctor aan
de Erasmus Universiteit Rotterdam
op gezag van de rector magnificus
prof. dr. P.W.C. Akkermans M.A.
en volgens het besluit van het college voor promoties

De openbare verdediging zal plaatsvinden op
woensdag 28 april 1999 om 13:45 uur.

door

Cornelia Theodora Maria van Rossum

geboren te Woerden

Promotiecommissie

Promotoren:	prof. dr. D.E. Grobbee prof. dr. J.P. Mackenbach
Co-promotor:	dr. H. van de Mheen
Overige leden:	prof. dr. ir. D. Kromhout prof. dr. F. Sturmans prof. dr. G.A.M. van den Bos

Acknowledgement

This study is part of the research program of the Erasmus Centre for Research on Ageing, a collaboration of the faculties of Economics, Law, Sociology, Medicine, and Health Policy and Management of Erasmus University Rotterdam and University Hospital Rotterdam Dijkzigt, The Netherlands. The author gratefully acknowledges the contribution of this centre.

For the analyses in the Whitehall Study, the author acknowledge the collaboration with the International Centre for Health & Society in London (Prof. M.G. Marmot). The author was supported for this specific project by the Dutch Heart Foundation and the Netherlands Organisation for Scientific Research (NWO).

The Rotterdam Study was supported by the NESTOR stimulation program for geriatric research in the Netherlands (Ministry of Health, Welfare and Sports, and Ministry of Education, Science and Culture), The Netherlands Organisation for Scientific Research (NWO), the Netherlands Prevention Fund and the municipality of Rotterdam.

Financial support by The Netherlands Heart Foundation for the publication of this thesis is gratefully acknowledged. Additional financial support by the Department of Epidemiology & Biostatistics, the Department of Public Health, and the Erasmus Centre for Ageing of the Erasmus University Rotterdam, and the Julius Centre for Patient Oriented Research of the Utrecht University Medical School is also gratefully acknowledged.

Vanaf de maan gezien is iedereen even groot.

Multatuli

Contents

1
Introduction

1.1 Background

1.1.1 Socioeconomic differences in health

Studies carried out in several Western societies have shown that people in a lower socioeconomic position suffer more from diseases and have a shorter life expectancy than people in a higher socioeconomic position.[1-4] It is important for health policy makers to understand socioeconomic differences in health. For example, it may be shown that people of a particular socioeconomic group share a certain lifestyle, so that some determinants of disease are more prevalent in this socioeconomic group. Studies on socioeconomic differences may then suggest potential interventions with respect to these determinants which will reduce differences in health between socioeconomic groups and improve the overall health of a population. In addition, studies on socioeconomic differences may also enhance the understanding of disease aetiology. For example, they may disclose new risk factors in relation to the social environment, if known risk factors could not explain all socioeconomic differences in health.

A socioeconomic gradient has been observed for almost any disease, but this thesis will focus only on socioeconomic differences in cardiovascular disease, a major cause of chronic morbidity and mortality.

In The Netherlands, the discussion about socioeconomic inequalities in health was mainly initiated by the first target of the 'Health-for-all-strategy' of the World Health Organisation[5]: 'By the year 2000 the differences in health status between countries and between groups within countries should be reduced by at least 25% by improving the level of health of disadvantaged nations and groups'. This statement was included in an important policy document published by the Dutch government in 1984.[6] Since then, the number of Dutch publications on socioeconomic inequalities has increased, showing that people in a lower socioeconomic position have higher morbidity and mortality rates compared to those in a higher socioeconomic position.[7-10]

1.1.2 Explanations for socioeconomic differences in health

Why are lower socioeconomic groups worse off with respect to their health? Two main explanations for socioeconomic differences in health have been proposed: (1) 'Health-related social mobility' and (2) 'Causation'.[11-13] Both explanations assume a true association, but differ with regard to the direction of the causal chain. Health-related social mobility implies that people either move down the social scale because of their health problems, or move up because of their good health. As a result, higher socioeconomic groups will mainly consist of healthy people and lower socioeconomic groups of relatively more unhealthy people. Two types of social mobility can be distinguished: intergenerational and intragenerational social mobility. Intergenerational mobility occurs when an adult's socioeconomic status is higher or lower than his/her parents socioeconomic status, while intragenerational mobility refers to a person's change in socioeconomic status compared to his/her own previous socioeconomic status.

The causation explanation implies that socioeconomic differences in health are caused by socioeconomic status. This impact of socioeconomic status on health is not direct, but it is indirect via a higher exposure to specific risk factors (= intermediary factors) in certain socioeconomic groups. Examples of these intermediary factors are: material factors, such as financial accessibility to medical care; behavioural factors, such as smoking and dietary habits; and biological factors, such as a high blood pressure and serum cholesterol, which are partially related to the previous factors. Unequal distribution of specific risk factors across groups of different socioeconomic status may lead to socioeconomic differences in health. So far, research has primarily focussed on the association between socioeconomic status and classic cardiovascular risk factors, such as smoking, cholesterol and diet. However, because these risk factors explain only a small proportion of inequalities,[14] mechanisms that bring about socioeconomic differences in health are also sought in social circumstances during childhood.[15,16] For instance, a greater susceptibility to disease later in life could be induced for people that grew up in poor material circumstances.[17] Attention is also paid to psychosocial factors as intermediary factors in the association between socioeconomic status and health.[18] For example, lower socioeconomic groups may live in more stressful conditions or may be less able to cope with stress.

Figure 1.1 shows a simplified model that has been adopted in this thesis to explain the association between socioeconomic status and cardiovascular disease. The explanation on the basis of health-related social mobility is indicated by relation '1'. An example of this mechanism is a patient with a myocardial infarction who is no longer able to work and whose income will decrease. In other words, a health problem is the cause of his declining socioeconomic status. In general, the contribution of this explanation to the socioeconomic differences in health is assumed to be only modest.[9] The causation explanation, via intermediary factors, is indicated in the figure by relation '2'. First, socioeconomic status, measured by data on e.g. education, occupation or income, is associated with intermediary factors, most notably cardiovascular risk factors. Behavioural factors (e.g. lack of physical activity,[19-21] smoking habits,[19-22] eating habits,[19,23,24]) as well as biological factors (e.g. elevated blood pressure,[19-21] higher plasma fibrinogen levels[25-28])

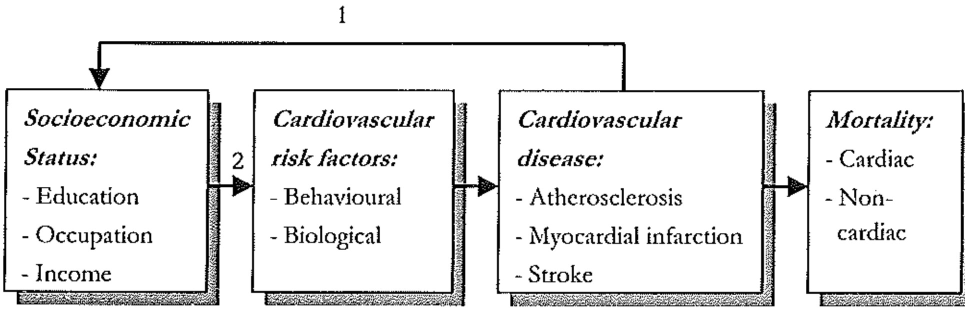


Figure 1.1 Model of the association between socioeconomic status and cardiovascular morbidity and mortality.

are distributed in different ways across socioeconomic groups. Subsequently, this unequal distribution of risk factors will lead to a higher prevalence and incidence of cardiovascular disease and to higher mortality rates in especially the lower socioeconomic groups.[29] Material factors, such as accessibility to use of medical care and psychosocial factors,[30-32] also act as intermediary factors for the association between socioeconomic status and cardiovascular morbidity and mortality, although these will not be discussed in this thesis.

Most of the evidence for the association between socioeconomic status and cardiovascular risk factors, cardiovascular mortality and cardiovascular morbidity is based on studies from outside The Netherlands. However, the limited range of data from Dutch studies does not suggest that the situation in The Netherlands is very different from other western countries.[33]

1.1.3 Socioeconomic differences in health among elderly people

Although socioeconomic inequalities in health occur at any age, from birth into old age, most studies have been done among persons who are younger than 65. Since cardiovascular mortality rates and morbidity rates have declined in younger age groups,[34] health inequalities among middle-aged persons are losing significance and meaning, whereas health inequalities among the growing number of elderly people may have been gaining importance.

The question arises whether inequalities still exist into old age, and whether they decrease or increase with age. There are two contrasting views.[35,36] According to one view, socioeconomic inequalities will be less clear at older ages than they are at younger ages. It is argued that the inequalities at younger ages will have eliminated the more vulnerable individuals from the population. Due to selective mortality, socioeconomic differences in health will be less pronounced at older ages. Furthermore, the distribution of some risk factors will become more equal across the different socioeconomic groups at older ages. The direct effect of the work environment, for example, will disappear.

The alternative view assumes that the factors that contribute to socioeconomic differences in health at younger ages maintain their effect into old age. This view argues that inequalities will be larger due to a cumulative effect of exposure to all the risk factors for diseases over a prolonged period of time.

Despite the evident need to study socioeconomic differences among elderly people, they have so far received little attention, especially among elderly women. One of the reasons could be that fewer epidemiological studies have been carried out among women and elderly people than among men and younger persons. Furthermore, the measurement of socioeconomic status in older age groups is more complicated. For example, it may not be possible to assess current occupational status because most elderly persons are retired. Income level too, is difficult to assess since the cost of living in a nursing home or home for the elderly is higher than the actual income. This means that those living in such a home will have to pay the maximum contribution possible, leaving only a small amount of pocket money to be spent at their own discrete.

In The Netherlands, socioeconomic differences among elderly persons have been reported for chronic disorders, such as chronic bronchitis, lung diseases, and diabetes;[37] for perceived general health;[37-40] and for disability[41]. Socioeconomic differences have also been found in the prevalence of psychiatric and cognitive disorders[37,38,42] and in incidence of dementia, in particular Alzheimer's disease.[43,44] To our knowledge, only one study on socioeconomic differences in cardiovascular disease among elderly persons has been conducted in The Netherlands. This study among persons aged 55-75 years showed a higher prevalence of heart disorders in lower occupational groups.[37] However, only data on occupational status was available in this study and no longitudinal data on cardiovascular disease was gathered.

1.2 Objectives

The aim of the studies in this dissertation is to study in more detail socioeconomic differences in mortality and cardiovascular disease among elderly people. The research has mainly been conducted as part of the Rotterdam Study, a prospective follow-up study among elderly people who live in a suburb of Rotterdam. This study gave us the opportunity to examine socioeconomic inequalities among elderly men and women and to examine this in a longitudinal study design. The main research questions are:

(1) Do socioeconomic differences in all cause mortality and cardiovascular mortality exist among elderly men and women?
(2) Do socioeconomic differences in the prevalence and incidence of cardiovascular disease exist among elderly men and women?

(3) Do socioeconomic differences in cardiovascular risk factors exist that can explain the association between socioeconomic status and mortality or cardiovascular morbidity among elderly men and women?

Furthermore, some analyses have been done in the first Whitehall Study, a study with a long follow-up in which it was possible to distinguish the younger age groups from the older age groups and to examine whether the socioeconomic differences were the same for all specific causes of death. In addition, the question was answered whether the effect of season on mortality was larger for those with a lower employment grade and other high risk groups.

1.3 Study population

This section gives a short overview of the study populations, the Rotterdam Study and the First Whitehall Study, that were used to answer the research questions in this thesis.

1.3.1 The Rotterdam Study

Aim and rationale

Elderly people form a substantial and growing part of the population. Age related illnesses with chronic characteristics affect large numbers of people and have a dramatic impact on the quality of life. The Rotterdam Study focuses on the study of aetiology of disease by investigating incidence and determinants of occurrence of important chronic diseases, in particular, neurogeriatric diseases, cardiovascular diseases, locomotor diseases and ophthalmologic diseases.[45]

The aim of the Rotterdam Study is twofold:[45]

(1) To investigate determinants of chronic diseases in order to assess etiologic significance.
(2) To investigate potentially modifiable determinants in order to be able to provide specific recommendations that once confirmed by intervention studies may be developed into preventive strategies.

Design and methods

The Rotterdam Study is a prospective follow-up study. At baseline, in 1990-1993, all participants were extensively examined during a home interview and during two visits at the research centre. A first re-examination took place in 1993 to 1994 and a second started in 1997. Furthermore, incident morbidity causes of death were recorded via the general practitioners of the participants from the beginning of the study in 1990 till now.

The study design was approved by the Medical Ethics committee and each participant was asked to sign a consent form.

The study population was defined as all inhabitants aged 55 years and older of one district of Rotterdam (Ommoord), who lived there at a specific point in time. From the eligible subjects, 4,878 women and 3,105 men were willing to participate (78%). The non-response was higher in the older subjects, especially among those older subjects living independently. The mean age was 69 years with a range from 55 to 106.

During the baseline measurements information on most determinants and prevalence of diseases was gathered. The measurements comprised medical history, dietary history, medical complaints, pharmacotherapy, socioeconomic status, geriatric status, physical examination, ophthalmological examination, laboratory examination, electrocardiographs and bone density. During the second phase (re-examination), as far as possible, similar procedures as during the baseline measurements were used. The information from the second phase of the study is only used in Chapter 4.2 of this thesis.

Detailed information on incident morbidity and vital status was obtained from the general practitioners of the participants. Most general practitioners involved, have their practice computerised and reported all possible incident cases and deaths to the research centre. For the participants with a general practitioner not linked to the computer system, information was retrieved from medical records by research physicians. In addition, information on vital status was obtained from the municipal authorities of Rotterdam. When an event or death was reported, additional information was obtained from interviewing the general practitioner and from hospital discharge records in case of admittance or referral. Two research physicians independently classified all suspected events (for instance date of event, certainty of diagnosis, ICPC code) using all available information. If there was disagreement a consensus was reached. Finally, a medical expert in the field of cardiovascular disease whose opinion was decisive for the final classification, verified all events.

1.3.2 The first Whitehall Study

Aim and rationale

The purpose of the Whitehall Study was to translate knowledge about precursors and early manifestations of cardiorespiratory diseases into effective public health action. Till then, this had not been previously done on an adequate scale in Britain.[46]

The aims of the first Whitehall Study were:[46]

(1) To evaluate mass screening for cardiorespiratory conditions with respect to yield of previously unrecognised disease and risk factors, organisation and use of non-medical personnel.
(2) To determine the effect of risk factors and to evaluate the ability of simple mass examinations to predict future cases of major cardiorespiratory diseases.

Design and methods

The Whitehall Study is a prospective follow-up study. At baseline of the study between September 1967 and January 1970, all non-industrial male Civil Servants aged 40 years and over and working in departments within approximately two miles of Whitehall in London, who were listed by the personnel sections, were invited to participate in this study. In total, 19,019 men aged 40-69 years attended this initial screening.

At baseline of the study, subjects had to complete a questionnaire on their age, job, residence and relevant familial and previous medical history. Employment grade was categorised as administrative, professional and executive, clerical, and 'other' grades (e.g. messengers and other unskilled manual workers). Standardised questions were included on cardiorespiratory diseases and smoking and on symptoms of diabetes. During the survey, height, blood pressure, skinfold thickness, expiratory volume, electrocardiogram, serum cholesterol and chest radiographs were assessed.

Detailed information on mortality was obtained at the National Health Service Central Registry, which notified all deaths. The analyses in this theses are based on all deaths up to the end of January 1995, thus a follow-up for at least 25 years. Causes were classified according to the International Classification of Disease, eighth revision (ICD-8).

1.4 Chapter outline

Since nearly all analyses in this dissertation are based on data from the Rotterdam Study, a description of the socioeconomic status of this study population will be given in Chapter 2. Chapter 3 deals with socioeconomic differences in mortality among Dutch elderly people and among civil servants from the first Whitehall Study. Studies on socioeconomic variation in several cardiovascular diseases are described in Chapter 4. This chapter comprises a discussion about the explanation of the socioeconomic inequalities in cardiovascular disease by variation in cardiovascular risk factors. Two risk factors, 'dietary habits' and 'hypertension', are described in detail in Chapter 5. Finally, Chapter 6 comprises a general discussion about the results of the foregoing chapters.

1.5 References

1. Marmot MG, Kogevinas M, Elston MA. Social/economic status and disease. *Annu Rev Public Health* 1987;8:111-35.
2. Fox J, ed. *Health inequalities in European countries.* Aldershot: Gower Publishing Company Limited, 1989:414.
3. Illsley R. Health inequities in Europe. Comparative review of sources, methodology and knowledge. *Soc Sci Med* 1990;31:229-36.

4. Mackenbach JP, Kunst AE, Cavelaars AE, Groenhof F, Geurts JJ. Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet* 1997;349:1655-9.

5. World Health Organisation. *Health for all targets. The health policy for Europe.* European Health for All Series no 4. Copenhagen: WHO, 1993.

6. Anonymous. *Nota 2000, over de ontwikkelingen van gezondheidsbeleid feiten, beschouwingen en beleidsvoornemens [in Dutch].* Tweede Kamer, vergaderjaar 1985-1986, 19500, nrs 1-2.

7. Stronks K, Mackenbach JP. Recent Nederlands onderzoek op het gebied van sociaal-economische gezondheidsverschillen [in Dutch]. *Tijdschr Soc Gezondheidsz* 1988;66:349-54.

8. Spruit IP. Health and social inequities in The Netherlands. *Soc Sci Med* 1990;31:319-29.

9. Mackenbach JP. Socio-economic health differences in The Netherlands: a review of recent empirical findings. *Soc Sci Med* 1992;34:213-26.

10. Mackenbach JP. Socioeconomic inequalities in health in the Netherlands: impact of a five year research programme. *BMJ* 1994;309:1487-91.

11. Townsend P, Davidson N, Whitehead M, ed. *Inequalities in health (The Black Report* & *The health Divide).* London: Penguin Books, 1988.

12. Fox AJ, Goldblatt PO, Jones DR. Social class mortality differentials: artefact, selection or life circumstances? *J Epidemiol Community Health* 1985;39:1-8.

13. Marmot M, Bobak M, Davey Smith G. *Explanations for social inequalities in health* Amick III BC, Levine S, Tarlov AR, ed. Society & Health. New York/Oxford: Oxford University Press, 1995: 172-210.

14. Marmot MG, Rose G, Shipley M, Hamilton PJ. Employment grade and coronary heart disease in British civil servants. *J Epidemiol Community Health* 1978;32:244-9.

15. van de Mheen H, Stronks K, Looman CW, Mackenbach JP. The contribution of childhood environment to the explanation of socio-economic inequalities in health in adult life: a retrospective study. *Soc Sci Med* 1997;44:13-24.

16. Davey Smith G, Hart C, Blane D, Hole D. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. *BMJ* 1998;316:1631-5.

17. Marmot MG. *Social inequalities in mortality: the social environment* In: Wilkinson RG, ed. Class and Health. London: Tavistock, 1986:21-33.

18. Anderson NB, Armstead CA. Toward understanding the association of socioeconomic status and health: a new challenge for the biopsychosocial approach. *Psychosom Med* 1995;57:213-25.

19. Bennett S. Cardiovascular risk factors in Australia: trends in socioeconomic inequalities. *J Epidemiol Community Health* 1995;49:363-72.

20. Hoeymans N, Smit HA, Verkleij H, Kromhout D. Cardiovascular risk factors in relation to educational level in 36 000 men and women in The Netherlands. *Eur Heart J* 1996;17:518-25.

21. Luoto R, Pekkanen J, Uutela A, Tuomilehto J. Cardiovascular risks and socioeconomic status: differences between men and women in Finland. *J Epidemiol Community Health* 1994;48:348-54.

22. Holme I, Helgeland A, Hjermann I, Lund-Larsen PG, Leren P. Coronary risk factors and socioeconomic status. The Oslo study. *Lancet* 1976;2:1396-8.

23. Davey Smith G, Brunner E. Socio-economic differentials in health: the role of nutrition. *Proc Nutr Soc* 1997;56:75-90.

24. Hulshof KF, Löwik MR, Kok FJ, Wedel M, Brants HA, Hermus RJ, ten Hoor F. Diet and other life-style factors in high and low socio-economic groups (Dutch Nutrition Surveillance System). *Eur J Clin Nutr* 1991;45:441-50.

25. Moller L, Kristensen TS, Hollnagel H. Social class and cardiovascular risk factors in Danish men. *Scand J Soc Med* 1991;19:116-26.

26. Markowe HL, Marmot MG, Shipley MJ, Bulpitt CJ, Meade TW, Stirling Y, Vickers MV, Semmence A. Fibrinogen: a possible link between social class and coronary heart disease. *BMJ* 1985;291:1312-4.

27. Wilson TW, Kaplan GA, Kauhanen J, Cohen RD, Wu M, Salonen R, Salonen JT. Association between plasma fibrinogen concentration and five socioeconomic indices in the Kuopio Ischemic Heart Disease Risk Factor Study. *Am J Epidemiol* 1993;137:292-300.

28. Brunner E, Davey Smith G, Marmot M, Canner R, Beksinska M, O'Brien J. Childhood social circumstances and psychosocial and behavioural factors as determinants of plasma fibrinogen. *Lancet* 1996;347:1008-13.

29. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.

30. Stronks K, van de Mheen H, Looman CW, Mackenbach JP. The importance of psychosocial stressors for socio-economic inequalities in perceived health. *Soc Sci Med* 1998;46:611-23.

31. Kessler RC, Cleary PD. Social class and psychological distress. *Am Sociol Rev* 1980;45:463-78.

32. Valkonen T. Psychosocial stress and sociodemographic differentials in mortality from ischaemic heart disease in Finland. *Acta Med Scand Suppl* 1982;660:152-64.

33. Kunst AE. *Sociale ongelijkheid en hart- en vaatziekten: een literatuurstudie [in Dutch]* Rotterdam: Department of Public Health, Erasmus University, 1990.

34. Olshansky SJ, Ault AB. The fourth stage of the epidemiologic transition: the age of delayed degenerative diseases. *Milbank Q* 1986;64:355-91.

35. Dahl E, Birkelund GE. Health inequalities in later life in a social democratic welfare state. *Soc Sci Med* 1997;44:871-81.

36. Jefferys M. Social inequalities in health-do they diminish with age? *Am J Public Health* 1996;86:474-5.

37. van den Bos GAM. *Zorgen van en voor chronisch zieken [in Dutch]* [Dissertation]. Amsterdam: University of Amsterdam, 1989.

38. Bosma A. *De gezondheid van mensen in de derde levensfase; onderzoek naar lichamelijke en psychische aspekten [in Dutch].* Eindhoven: GGD Eindhoven, afd. Preventieve & Soc. Psychiatrie Eindhoven, 1988: 119-26.

39. Mentjens MFMH, Lapperre-Rengelink M, Aben DJM. *Peiling naar de toekomstige woon- en zorgwensen van ouderen in de regio Geldrop-Valkenswaard (deel 1) [in Dutch]* Geldrop: GGD Regio Geldrop-Valkenswaard, 1990.

40. Reijneveld SA, Gunning-Schepers LJ. Age, health and the measurement of the socio-economic status of individuals. *Eur J Public Health* 1995;5:187-92.

41. van den Bos GAM, Lenoir ME. *Sociale ongelijkheid in chronische aandoeningen, beperkingen en zorggebruik [in Dutch].* Amsterdam: Instituut Sociale Geneeskunde, Universiteit Amsterdam, 1991.

42. Breteler MMB. *Cognitive decline in the elderly. Epidemiologic studies on cognitive function and dementia* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1993.

43. Ott A, Breteler MM, van Harskamp F, Claus JJ, van der Cammen TJ, Grobbee DE, Hofman A. Prevalence of Alzheimer's disease and vascular dementia: association with education. The Rotterdam study. *BMJ* 1995;310:970-3.

44. van Duijn CM. *Risk factors for Alzheimer's disease* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1992.

45. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

46. Reid DD, Brett GZ, Hamilton PJ, Jarrett RJ, Keen H, Rose G. Cardiorespiratory disease and diabetes among middle-aged male Civil Servants. A study of screening and intervention. *Lancet* 1974;1:469-73.

Socioeconomic Status
The Rotterdam Study

2.1 Introduction

The studies reported on in this thesis are mainly conducted as part of the Rotterdam Study, a prospective study among 7,983 persons aged 55 years and over (see Chapter 1.3). Measuring socioeconomic status in this age group poses some challenges. In this chapter an overview is given of the indicators of socioeconomic status and their meaning and limitations for (Dutch) elderly people. This is followed by a description of the measurement and distribution of socioeconomic status in the Rotterdam Study. Attention is also paid to the socioeconomic status of participants in this study population compared to that of the whole Dutch elderly population.

2.2 Measuring socioeconomic status in an older population

In studies on socioeconomic inequalities in health, the sociological principle that societies are stratified prevails. This stratification results from and also determines the ranking of individuals in terms of knowledge, prestige, power or material resources. A person's position in this social stratification is indicated by the term socioeconomic status.[1]

The most widely used indicators for socioeconomic status are 'education', 'income' and 'occupation'.[2] Although these indicators may overlap slightly, each indicator reflects a different aspect of a person's socioeconomic status. Educational level reflects someone's knowledge and also the ability and willingness to acquire new knowledge. The indicator 'occupation' stands for prestige and occupational hazards and 'income' reflects the material conditions and resources of socioeconomic status.

The same indicators are used to assess socioeconomic status in an ageing population, although here, specific limitations apply, since most measures of socioeconomic status were developed with working men in mind. For example, the majority of elderly persons is no longer economically active and cognitive decline also complicates the measurement of socioeconomic status. The next section contains an overview of the above-mentioned indicators, their meaning and limitations when applied to an elderly (Dutch) population.

2.2.1 Education

The indicator 'education' is usually measured on the basis of either the attained level of education or the number of years of education. The latter is not very suitable, since the number of years would be misclassified for those who attained additional education as a part-time student. As a consequence, the number of years of education would be overestimated. Therefore, among elderly people, the indicator 'education' should be measured on the basis of the attained level of education.

An advantage of this indicator above other indicators is that it is not affected by recent changes in family structure, such as getting widowed. A disadvantage with respect to elderly people is that the majority attended primary school only. In other words, it fails to differentiate for the majority of the population. Nevertheless, several studies have shown the usefulness of this indicator in older age groups.[3] In the younger birth cohorts, this issue is only a minor problem since more people completed secondary school.

It is also unclear whether the meaning of education as indicator for socioeconomic status has remained the same across all birth cohorts: access to education has changed over time and nowadays a high education may not invariably lead to a high occupation and high income as a matter of course.

2.2.2 Occupation

Occupational status is usually based on someone's current occupation. Since the majority of elderly persons is no longer economically active, one is forced to think about alternative measurements. In fact, the discussion about the best measurement of occupational status is not unique to elderly people. In several studies, measurements on the basis of last, longest or highest occupation or on the basis of a weighted average of the entire occupational history are in use as alternatives to current occupation.

Using last occupation has the disadvantage of a possible underestimation of occupational status because older people may take on less demanding jobs or consider work as a supplement to retirement lifestyle. In The Netherlands, however, intragenerational mobility (the changes in occupational level within one generation) is limited.[4] In other words, all these measurements would not differ a great deal. Since an accurate recall of one's own entire occupational history, with no missing values, is difficult to obtain, last or current occupation would be the most straightforward measure.

For women, in addition to occupational status on the basis of own occupation, occupational status on the basis of occupation of the head of the family, traditionally male, is also used. In the literature it is mentioned that both options have validity and that there is no clear preference for one in particular.[2] Women's own occupation has the disadvantage that most women in the older age group had a paid job a long time ago, because it was very common at that time that women became housewives after they got married. However, measuring the occupation of the head of the household has its problems too. The difficulty here lies in the fact that among elderly people, there is a high percentage of widowed and divorced persons. Again, this is not restricted to elderly people, despite the higher percentage. The question is whose occupation determines best the socioeconomic status after death of the spouse or after divorce: occupation of former husbands or women's own jobs? This issue has not yet been sufficiently studied in order to be able to favour a specific approach.

2.2.3 Income

'Income' has an attractive quantitative and direct image. However, here also difficulties may arise. The main problem is the different financial situation for persons living in a home for the elderly or a nursing home on the one hand, and non-institutionalised, or independent, persons on the other hand. Is income defined as the actual income or as the income minus the contribution for the cost of living in a home for the elderly? In most cases, the cost is higher than actual income, which means that only a small amount of money for own expenses.

In addition, a recent retirement, divorce or death of the spouse might influence the measurement of current income. Therefore, one may question whether a weighted average of lifetime earnings or maximum earnings to date would best represent someone's socioeconomic status. However, in practice, it is not feasible to obtain all the required information.

2.3 Measurement of socioeconomic status in the Rotterdam Study

The Rotterdam Study is a prospective cohort study among 7,983 persons of 55 years and over at the time of the baseline examination (1990-1993), who live in one defined geographic area in Rotterdam, The Netherlands. The rationale and design of the study have been described previously (see also Chapter 1.4).[5] For the assessment of socioeconomic status in this ageing population, we have as much as possible considered the restrictions mentioned in the previous section.

Data on socioeconomic status were obtained by trained interviewers who visited the participants at home between 1990 and 1993, thereby assisted by a computer. The three most important indicators of socioeconomic status were assessed: education, income and occupation. For women, occupation of the head of the household was also measured.

2.3.1 Education

The participants were asked to recall details about their formal education, the number of years spent in education, and whether they had completed their education. The interviewers had a list with seven categories containing also the most common accompanying education types. Where possible, the interviewers classified the education types mentioned in the interview into one of these categories (see Table 2.1). The remaining unclassified education types were described and later coded on the basis of a Dutch standardised classification of education types.[6] These so-called SOI-codes were subsequently transformed into the seven categories mentioned above. From all this information, the highest attained level of education was defined. In this chapter, the seven categories are aggregated into four categories, similar to the UNESCO classification (see Table 2.1).[7] Information about education was available for 95% of the participants.

Table 2.1 *Categories of education.*

1.	Primary education
2.	Lower vocational education*
	Lower and intermediate general education†
3.	Intermediate vocational education‡
	Higher general education§
4.	Higher vocational education ‖
	University#

Dutch examples:
* 'LTS', 'Nijverheidschool', 'Ambachtschool'
† '3-jarige HBS', 'ULO', 'MAVO'
‡ 'Kleuterkweekschool', 'MTS', 'Politieschool'
§ '5-jarige HBS', 'MMS', 'Gymnasium', 'HAVO'
‖ 'Hogere laboratoriumschool, 'Kweekschool', 'MO-A', 'Hogere zeevaartschool'
'Doctoraal-examen oude en nieuwe stijl'

2.3.2 Occupation

In the Rotterdam Study, a complete occupational history was obtained including every job title, the number of employees for each occupation and employment status (self-employment or employment). For current or last occupation, a description of the type of work and type of business was also obtained. The occupational titles were coded by means of a Dutch occupation classification.[8] These codes were transformed into a classification based on the Erikson-Goldthorpe-Portocarero (EGP) scheme.[9] This transformation was developed by Ganzeboom[10] and uses information on job titles, number of employees and employment status. The EGP-scheme of 10 categories was compressed into a classification of five categories (see Table 2.2). The majority of our study population had retired. Therefore, we used current (10%) occupation for those still working and last occupation (80%) for those no longer working as indicators for socioeconomic status. For the remaining 10%, no data were available. Also people's first occupation was defined on the basis of job history details and was classified into the EGP-scheme.

In addition to women's own occupation, occupation of the head of the household was also defined. Participants were asked in the interview about the occupation of their partner. For women living with a partner and for widows, the spouse was considered the head of the household. For women that were divorced and living without partner, she herself was considered head of the household. The occupational classification for head of

Table 2.2 Categories of occupation.

Categories of occupation*	Examples
Higher and lower grade professionals; administrators and officials; higher-grade technicians; managers in small businesses and industrial establishments; large proprietors; supervisors of non-manual employees.	Principal, rector of an educational establishment, scientist, head nurse, branch manager, policeman, teacher with a primary school, purchaser.
Routine non-manual employees in administration and commerce; sales personnel; other rank-and-file office workers.	Sales clerk, secretary, operator, administrative civil servant, insurance agent.
Small entrepreneurs; artisans with and without employees; farmers and smallholders; self-employed fishermen.	Cafe-owner, wholesaler, shopkeeper, artisan with and without employees, farmer and smallholder.
Skilled manual workers; lower grade technicians; supervisors of manual workers.	Executors, foremen, telephone fitters, guards, carpenters, lathe operators, painters.
Semi- and unskilled manual workers; agricultural workers.	Maid, cleaner, waiter, farm labourer, in-market gardener.

* The categories of occupation will be mentioned in the next chapters with the description in bold print.

the household was done similar to own occupation; information was available for 90% of female participants.

2.3.3 Income

The indicator 'income' was defined as the monthly net income of all members of the household. Participants classified their net household income into one of 13 pre-coded categories (see Table 2.3). The interviewers were informed as to the elements that are included and excluded from this income. In addition to net salary or payment, net income includes: salary of a 13th month, children's allowance, interest on property, maintenance, family allowance, holiday allowance. Not included in the net income were house rent subsidy,

Table 2.3 Categories of net income of the household.

< ƒ1,000 per month
≥ ƒ1,000 - < ƒ1,400 per month
≥ ƒ1,400 - < ƒ1,700 per month
≥ ƒ1,700 - < ƒ1,900 per month
≥ ƒ1,900 - < ƒ2,100 per month
≥ ƒ2,100 - < ƒ2,400 per month
≥ ƒ2,400 - < ƒ2,700 per month
≥ ƒ2,700 - < ƒ3,000 per month
≥ ƒ3,000 - < ƒ3,500 per month
≥ ƒ3,500 - < ƒ4,200 per month
≥ ƒ4,200 - < ƒ5,000 per month
≥ ƒ5,000 - < ƒ5,800 per month
≥ ƒ5,800 per month

medical cost subsidy, reimbursements for travel or college expenses and gifts. Besides income itself, the number of persons living on that income was also indicated. Since in some households, more than one person depends on one income, household income was adjusted for number of household members. The correction was done by dividing the midpoint of each category by the number of persons living on that income to the power 0.36.[11] The outcome of this formula is what is called 'equivalent household income'. Residents in a home for the elderly (11%) were excluded from the income analyses as their financial situation differs from people that live independently. Five categories of equivalent income were defined (see Table 2.5), corresponding approximately to quintiles, based on the distribution of the study population. Information about equivalent income was available for 89% of people that live independently.

2.4 Distribution of socioeconomic status in the Rotterdam Study

The distributions of the indicators for socioeconomic status as well as the characteristics of the study population were separately described for men and women. All analyses were done separately for men and women, because men and women might differ in the assessment of a certain socioeconomic status and in the impact socioeconomic status has on health.[12] Spearman rank correlation coefficients were used to measure the relation between various indicators of socioeconomic status. To obtain insight into occupational

Table 2.4 Characteristics of the study population at baseline.

	Men	Women
Age in %	*n=3,105*	*n=4,878*
55 - 64 years	37.4	31.9
65 - 74 years	37.8	31.4
75 - 84 years	19.9	23.8
85 years and older	4.9	12.9
'Marital status' in %	*n=2,662*	*n=4,375*
No partner	2.6	7.6
With partner	83.7	50.8
Widowed	10.4	35.6
Divorced	3.3	6.0
Living situation in %	*n=3,105*	*n=4,878*
Independent	94.0	85.4
In a home for elderly	6.0	14.6

patterns within one generation, the so-called intragenerational occupational patterns, the association between the level of someone's first and last occupation was assessed by means of Chi-square analyses.

Table 2.4 shows the characteristics of the study population. The population comprised more women than men. The mean age of women was higher than of men, i.e. 72 and 69 years respectively. The majority, 84% of men and 51% of women lives with a partner. Consequently, the proportion of widowed and divorced women was higher than the proportion of widowed and divorced men. Most people live independently.

Table 2.5 shows the distribution of the socioeconomic indicators. In general, the indicators for socioeconomic status were unequally distributed for men and women. For instance, the average equivalent income of men was higher than that of women, i.e. ƒ2,364 and ƒ1,978 respectively. For men, 28% had only had primary education compared to 48% for women. Finally, women, compared to men, were more likely to be classified, on the basis of their own occupation, as semi- or unskilled manual workers or as routine

Table 2.5 Description of the socioeconomic status of the study population.

	Men	Women	
Education in %	*n=3,017*	*n=4,552*	
Higher vocational education and university	14.5	4.0	
Higher general and intermediate vocational education	35.1	19.2	
Lower general, intermediate general and lower vocational education	22.5	28.5	
Primary education	27.9	48.3	
	Own	*Own*	*Head of household*
Occupation in %	*n=2,975*	*n=4,257*	*n=4,350*
Professionals	33.3	10.8	27.6
Routine non-manual employees	25.8	43.1	28.5
Small proprietors	5.1	3.6	5.8
High/low skilled manual workers	21.6	2.3	19.0
Semi-/unskilled manual workers	14.2	40.3	19.1
Equivalent income in %	*n=2,609*	*n=3,701*	
> ƒ2,850	25.9	15.0	
> ƒ2,200 - ≤ ƒ2,850	26.4	20.4	
> ƒ1,750 - ≤ ƒ2,200	21.7	19.1	
> ƒ1,210 - ≤ ƒ1,750	16.1	18.4	
≤ ƒ1,210	9.9	27.0	

non-manual employees than as professionals. At the time of the baseline measurements, only 7% of all participants was still employed; the majority was older than 65 years and retired. On average, women's last paid job was 29 years ago, opposed to 9 years ago for men.

The change in distribution of education, income and occupation with age is shown in Figures 2.1 to 2.6. For all three indicators, lower socioeconomic groups were more prevalent in the older age groups. These differences by age may partly explain the differences in socioeconomic distributions between men and women. However, even within the same age groups, on average, men had a higher socioeconomic status than women did. These figures also show that the shape of the distribution differed for the various indicators: for example among men, the lowest occupational group was almost twice as large as the lowest educational group.

Table 2.6 shows that socioeconomic indicators were correlated with each other. All correlation coefficients were statistically significant and slightly more pronounced for men than for women. The correlation between education and occupation among women was more pronounced than the correlation coefficient between equivalent household income and the other indicators. Occupation of the head of the household was slightly more correlated with equivalent household income (0.38, not shown in table) than women's own occupation with income. This suggests that household income is determined more by men's income.

Table 2.6 Spearman correlation coefficients between indicators of socioeconomic status. The coefficients in the top-right part of the table represent the coefficients for men and the coefficients in the bottom-left part represent those for women.*

	Own education	Own occupation	Household income
Own education	-	♂ 0.42	♂ 0.47
Own occupation	♀ 0.43	-	♂ 0.40
Household income	♀ 0.32	♀ 0.24	-

* Adjusted for ties.

To obtain insight into the occupational patterns within one generation the so-called 'intragenerational occupational patterns', the association between the level of somebody's first and last occupation was assessed (see Table 2.7). As many women had a paid job a long time ago and as their first occupation was often also their last occupation, the majority of women remained 'immobile'. Men were more 'mobile' especially in the lowest occupational group. Although the occupational scheme is not completely ordinal, it can be stated that on average, men's occupational status moved up slightly during their lifetime. The Spearman rank correlation coefficient was 0.45 for men and even higher, 0.67, for women.

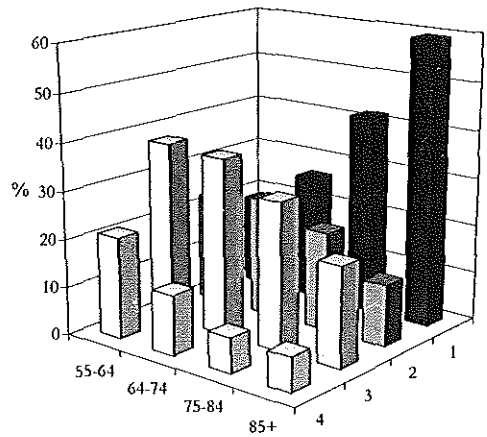


Figure 2.1 *Distribution of education by age* for men.*
1 = Primary education;
2 = Lower general, intermediate, general and lower vocational education;
3 = Higher general and intermediate vocational education;
4 = Higher vocational education, university.

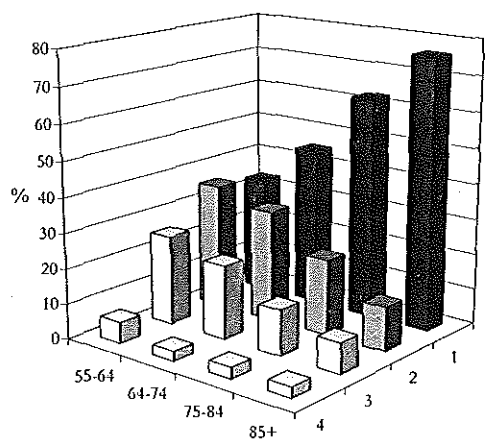


Figure 2.2 *Distribution of education by age* for women.*
1 = Primary education;
2 = Lower general, intermediate, general and lower vocational education;
3 = Higher general and intermediate vocational education;
4 = Higher vocational education, university.

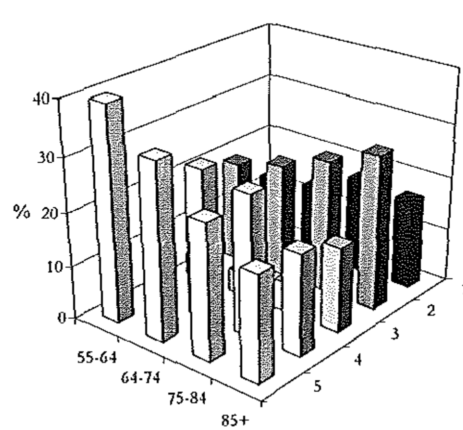


Figure 2.3 *Distribution of occupation by age* for men.*
1 = Semi-skilled and unskilled manual workers;
2 = High and low skilled manual workers;
3 = Small entrepreneurs;
4 = Routine non-manual employees;
5 = Professionals.

* The sum of the proportions within each age group is 100%.

(N.B: the y-scales are different)

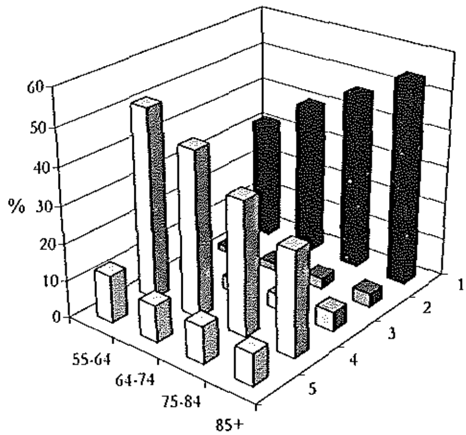


Figure 2.4 Distribution of own occupation by age for women.*
1 = Semi-skilled and unskilled manual workers;
2 = High and low skilled manual workers;
3 = Small entrepreneurs;
4 = Routine non-manual employees;
5 = Professionals.

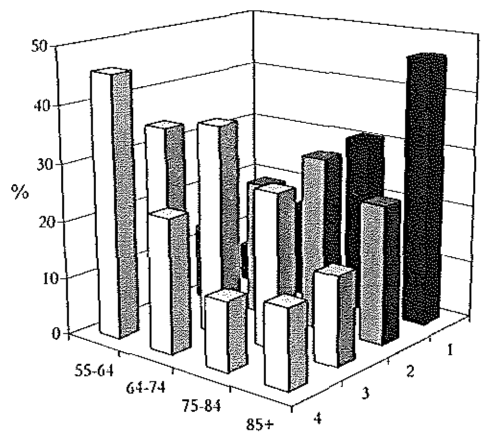


Figure 2.5 Distribution of equivalent income by age, for men.*
1 = ≤ f1,459;
2 = > f1,459 - ≤ f1,989;
3 = > f1,989 - ≤ f2,549;
4 = > f2,549.

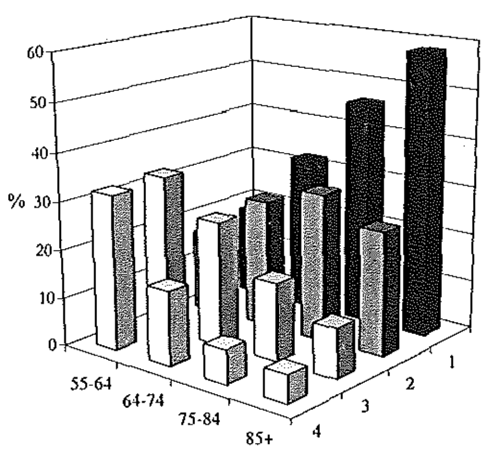


Figure 2.6 Distribution of equivalent income by age, for women.*
1 = ≤ f1,459;
2 = > f1,459 - ≤ f1,989;
3 = > f1,989 - ≤ f2,549;
4 = > f2,549.

* The sum of the proportions within each age group is 100%.

(N.B: the y-scales are different)

Table 2.7 First occupation and last/current own occupation for men and women in percentages (n=7,044).

First own occupation	%	(n)	Last/current own occupation 1	2	3	4	5
Men							
1. Professionals	15.3	(436)	81.9	8.0	2.8	3.9	3.4
2. Routine non-manual employees	26.3	(748)	31.1	55.3	4.5	4.8	4.1
3. Small proprietors	3.3	(93)	16.1	18.3	39.8	12.9	12.9
4. High and low skilled manual workers	35.7	(1,013)	22.4	14.0	3.8	44.9	14.8
5. Semi and unskilled manual workers	19.4	(551)	21.6	21.4	5.1	17.2	34.7
Total	100.0	(2,841)	33.5	25.6	5.3	21.6	14.0
Women							
1. Professionals	7.0	(296)	76.0	15.2	0.7	1.4	6.8
2. Routine non-manual employees	45.4	(1,910)	7.9	77.5	2.7	0.4	11.5
3. Small proprietors	1.8	(76)	1.3	9.2	76.3	2.6	10.5
4. High and low skilled manual workers	2.5	(107)	1.9	14.0	1.9	50.5	31.8
5. Semi and unskilled manual workers	43.2	(1,814)	4.1	14.6	24.2	28.0	83.4
Total	100.0	(4,203)	10.8	43.1	3.5	2.2	40.3

2.5 Distribution of socioeconomic status in the Rotterdam Study and The Netherlands

How does the distribution of the socioeconomic status in the Rotterdam Study compare to that in the same age groups in The Netherlands? Figures 2.7 shows the distribution of education in this study and in another Dutch study.[13] This study of the Dutch Central Bureau of Statistics (CBS) represented the total Dutch elderly population. Our study comprised less lower-educated people and more intermediate groups compared to the total Dutch population. For men, the distribution in the two studies differed more from each other compared to women. Furthermore, all educational levels are present in both study populations.

Although the absolute levels of household income are not fully comparable with each other due to a different method of data collection (self-reported versus registered information from tax offices) and to a different selection of the households (exclusion versus inclusion of the subjects living in a home for the elderly), a comparison of the distribution of household incomes between the households in the Rotterdam Study and

The Netherlands as a whole is shown in Figure 2.8. The frequencies of highest household incomes in the Rotterdam Study were lower, while the lowest income groups seemed more prevalent in our study population (see Figure 2.8). The peak in the lowest income groups mainly comprised older widowed women.

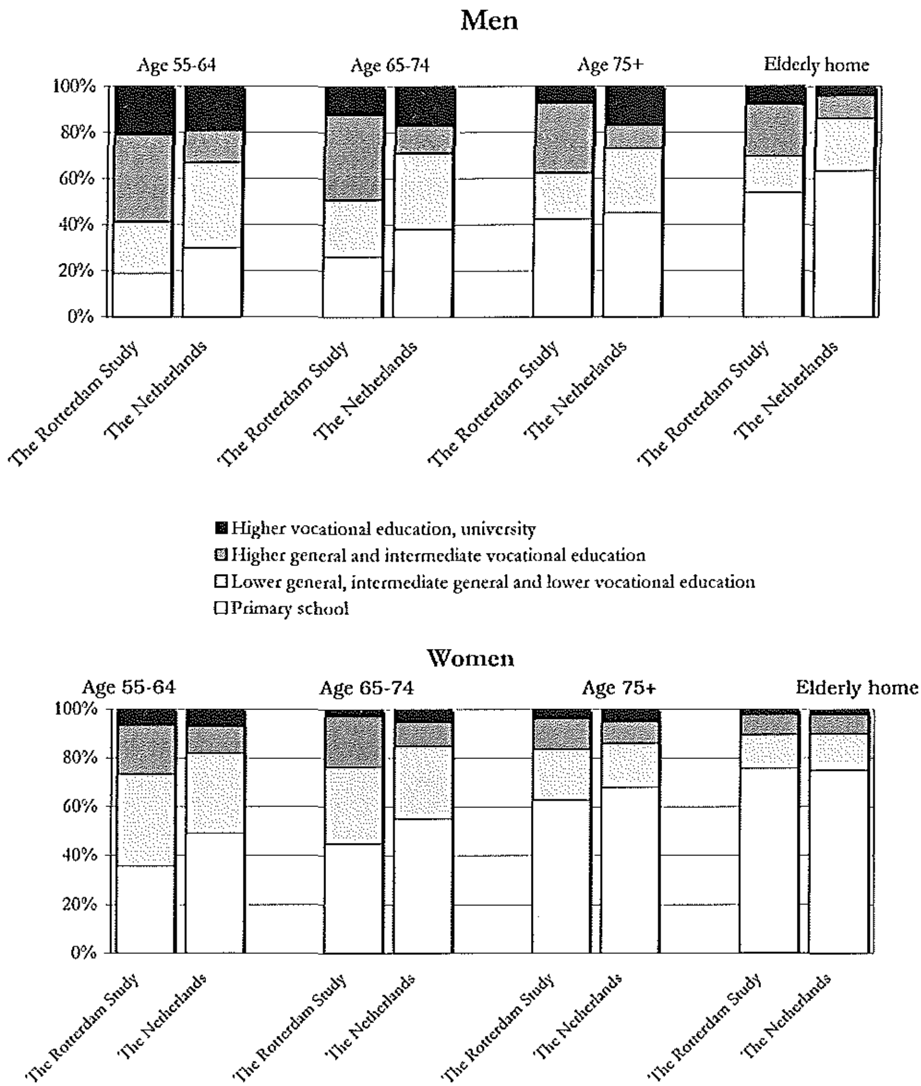


Figure 2.7 Distribution of education for men and women from the Rotterdam Study compared to The Netherlands as a whole.

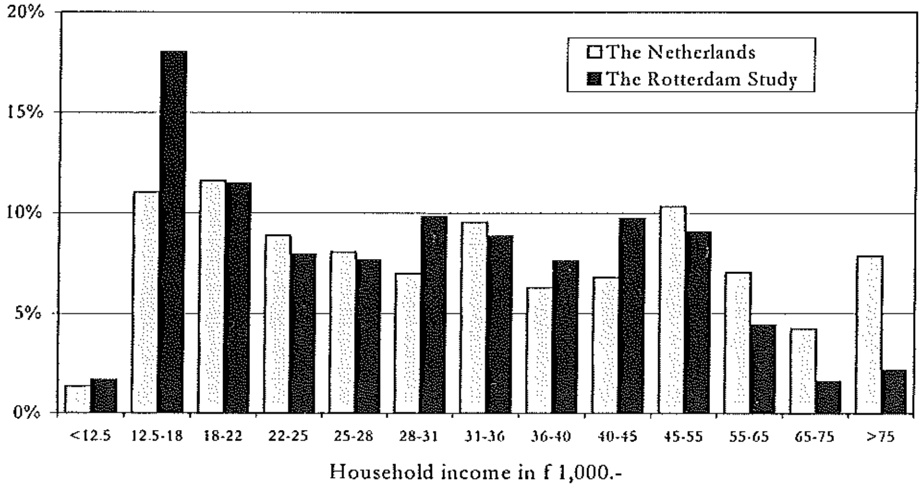


Figure 2.8 Distribution of household income for households in the Rotterdam Study compared to the Netherlands as a whole**

* Participants living in a home for the elderly are not included

2.6 Conclusion

This analysis shows that, on average, older men haved a higher socioeconomic status than women did. Furthermore, the findings show a trend in the socioeconomic status with age: the socio-economic status of the population decreases with age. These findings confirm the results of another study in The Netherlands showing a shift in occupation types and a shift in educational patterns with age.[4]

The observed correlation coefficients, range from 0.24 to 0.47, indicate that the indicators for socioeconomic status share some similar information, but they also reflect specific aspects of socioeconomic status. Compared to other studies, the slightly weaker correlation coefficients[14] might be due to our specific age groups. That is to say, in older birth cohorts, it was more likely to find a 'good job' during on the basis of primary school only.

In this thesis the association between socioeconomic status and cardiovascular disease is studied in the Rotterdam Study. We wanted to determine the extent to which out whether participants in the Rotterdam Study were representative for the Dutch elderly population as a whole with respect to socioeconomic status.

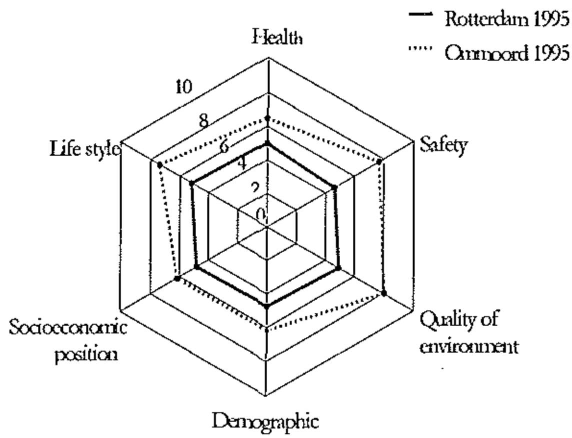


Figure 2.9 Health barometer for Ommoord and the average for Rotterdam

Source=Municipal Health Service rotterdamand surrounding area (GGD), 1998.

First, despite the high response rate in our study, the distribution of socioeconomic status could in theory be biased by non-response. It can be argued that the group of non-respondents comprised relatively more persons with a lower socioeconomic status. On the one hand, such a selection could have influenced the descriptive data such as in this chapter, but it is unlikely to affect the strength of associations between socioeconomic status and health or risk factors (as described in other chapters in this thesis). On the other hand, it could be that the more susceptible persons dropped out; the association between socioeconomic status and health and risk factors might have been stronger among these drop-outs (due to illness or death) compared to the association among those that participated in our study. We expect that, if anything, such a selection may have led to an underestimation of the socioeconomic differences in health.

Secondly, the generalisability needs to be considered. Were all socioeconomic groups represented in Ommoord and were participants from these socioeconomic groups representative for the socioeconomic groups in The Netherlands as a whole? Although the lowest and highest socioeconomic groups were less prevalent in our sample compared to the prevalences in The Netherlands as a whole, all socioeconomic groups were represented in our study population. Whether or not the various groups are representative is a more difficult question. In fact, this representativeness depends not only on the distribution of socioeconomic status, but also on whether the associations between socioeconomic status and all the intermediary factors in our study population are similar to those associations for The Netherlands as a whole.

A result of choosing a study population in one, quite homogeneous, region, such as Ommoord, is that a number of intermediary factors, such as neighbourhood conditions, housing conditions or health care services, are largely similar for everybody. Since these factors may also account for part of the socioeconomic inequalities in health in the total population,[15] part of the socioeconomic differences in health may not be detected in such a setting.

What are the environmental circumstances like in Ommoord? The Municipal Health Service has conducted a study in which they compared all the districts in Rotterdam with respect to several health-affecting factors at aggregated level.[16] Figure 2.9 shows these aspects for the district of Ommoord and for the whole of Rotterdam. A score higher than five for a specific aspect means a more favourable situation for this aspect compared to the average score for Rotterdam. Ommoord has a more favourable profile for all aspects on the 'health barometer', such as quality of the environment (e.g. number of residents per square meter), socioeconomic position (e.g. number of persons entitled to social benefit) or safety (e.g. number of police reports).

Thus, in studying socioeconomic differences in a homogeneous region like Ommoord, a part of the socioeconomic differences in health may not be detected. In other words, the socioeconomic differences found may be underestimated. The study can still provide important information about the socioeconomic differences in health resulting from other factors. Findings according to these other risk factors may be generalised to apply to the Dutch elderly population.

2.7 References

1. van Berkel-van Schaik AB, Tax B. *Naar een standaardoperationalisatie van sociaal-economische status voor epidemiologisch en sociaal-medisch onderzoek [in Dutch].* Rijswijk: Ministerie van WVC, 1990.
2. Liberatos P, Link BG, Kelsey JL. The measurement of social class in epidemiology. *Epidemiol Rev* 1988;10:87-121.
3. Martelin T. Mortality by indicators of socioeconomic status among the Finnish elderly. *Soc Sci Med* 1994;38:1257-78.
4. Dronkers J, Ultee WC, ed. *Verschuivende ongelijkheid in Nederland. Sociale gelaagdheid en mobiliteit [in Dutch].* Assen: Van Gorcum, 1995:335.
5. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.
6. C.B.S. (Dutch Central Bureau of Statistics). *Standaard onderwijsindeling 1978; codelijst van opleidingen, alfabetisch gerangschikt [in Dutch].* (1989 ed.). Voorburg: CBS, 1989.
7. Unesco. *International Standard Classification of Education (ISCED).* Paris, 1976.
8. C.B.S. (Dutch Central Bureau of Statistics). *Beroepenclassificatie 1984 [in Dutch].* Voorburg: CBS, 1984: 171.
9. Erikson E, Goldthorpe JH. *The constant flux.* Oxford: Clarendon Press, 1992.

10. Ganzeboom HBG, Luijkx R, Treiman DJ. Intergenerational class mobility in comparative perspective. *Res Social Stratification Mobility* 1989;8:3-84.

11. Buhmann B, Rainwater L, Schmaus G, Smeeding TM. Equivalence scales, well-being, inequality, and poverty: sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) data base. *Review of Income and Wealth* 1988;2:115-42.

12. Koskinen S, Martelin T. Why are socioeconomic mortality differences smaller among women than among men? *Soc Sci Med* 1994;38:1385-96.

13. Timmermans JM, de Boer A. *Rapportage Ouderen [in Dutch].* Rijswijk: Sociaal Cultureel Planbureau, 1992.

14. Abramson JH, Gofin R, Habib J, Pridan H, Gofin J. Indicators of social class. A comparative appraisal of measures for use in epidemiological studies. *Soc Sci Med* 1982;16:1739-46.

15. Stronks K. *Socio-economic inequalities in health: individual choice or social circumstances?* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1997.

16. GGD Rotterdam e.o. (Municipal Health Service Rotterdam and surrounding area). De gezondheidsbarometer. *Een geïntegreerde grafische buurtvergelijking [in Dutch].* Rotterdam: GGD Rotterdam e.o., 1998.

3
Socioeconomic status and mortality

3.1 Socioeconomic status and mortality. The Rotterdam Study

3.1.1 Abstract

Background. The aim of the study was to describe the relationship between socioeconomic status and mortality in Dutch elderly people.

Methods. A prospective follow-up study was performed among 4,878 women and 3,105 men aged 55 years and over living in Ommoord, a district of Rotterdam, The Netherlands. At baseline, data on education, occupation and income, were collected. Data on mortality was obtained from the municipal population registry and general practitioners. Relative risks of mortality by indicators of socioeconomic status were estimated after an average follow-up period of 4.1 years. Separate age-adjusted analyses were done for men and women.

Results. The findings in this study indicate that for men (mean age at baseline of 69 (SD 9) years), differences in mortality exist for all three indicators of socioeconomic status. Mortality risks were higher for lower educated men, unskilled manual workers and those with a lower equivalent household income. For women (mean age 72 (SD 10) years), the relative risks of mortality were also higher for lower educated groups, but lower equivalent household income and occupational status appeared not to be related to mortality.

Conclusions. In Dutch elderly people, there are clear differences in mortality across groups of different socioeconomic status. The mechanisms to explain the apparent inequalities in health among older subjects require further research.

3.1.2 Introduction

There is good data to show that in several Western countries mortality rates vary by indicators of socioeconomic status.[1-7] Evidence for this relationship, however, has mostly been obtained from studies among men younger than 65 years. In view of the increasing number of elderly people in the population,[8] the question arises whether an effect of socioeconomic status persists at older ages.[9,10] A cumulative effect of a lower socioeconomic status could augment the effect on mortality in the long run. Alternatively, class differences could become less important with ageing. For example, a direct effect of the working environment disappears[11] and the effect of background factors like age could be more important. Selective mortality could also have played a role: the inequalities at younger ages have removed the vulnerable individuals from the population.

Studies on socioeconomic mortality differences among elderly people are limited in number, but some of them have shown marked differences in mortality by socioeconomic status.[12-17] In addition, in most studies only one indicator of socioeconomic status is used, e.g. education, occupation or income. Although these indicators of socioeconomic status share some overlap, each indicator reflects another dimension of the socioeconomic status of a person. A study with more indicators of socioeconomic status could be of importance in indicating the most meaningful indicator of socioeconomic status for this specific age group.

The objectives of the present study were, first, to describe the differences in all cause mortality in older men and women by three indicators of socioeconomic status. Second, to assess the independent effects of each indicator of socioeconomic status.

3.1.3 Subjects and methods

Study population

The present study forms a part of the Rotterdam Study, a prospective cohort study among 7,983 persons aged 55 years and above, living in one defined geographic area in Rotterdam, The Netherlands. The rationale and design of the study have been described elsewhere.[18] In short, the objective of the Rotterdam Study is to investigate determinants of chronic and disabling cardiovascular, neurogeriatric, locomotor- and ophthalmologic diseases. All inhabitants aged 55 years and older, living in the district of Ommoord were invited to participate. The response rate was 78% (=7,983). The study has been approved by the Medical Ethics Committee of Erasmus University. Written informed consent was obtained from all participants.

Measurements

Information on socioeconomic status was obtained by trained interviewers who visited the participants between 1989 and 1993 at their home. Data on education, occupation and income were assessed.

Education The participants were asked about all formal education, the number of years of each type of education and whether they had completed it. From this information, the highest level of education attained was defined. This classification was similar to the UNESCO classification[19] and contains four categories: primary education; lower/intermediate general and lower vocational education; higher general and intermediate vocational education; higher vocational education and university. Information on education was available for 95% of the subjects.

Occupation In the Rotterdam Study a complete occupational history was obtained including all occupational titles, the number of employees and employment status (self-employment or in employment). For this study, the current occupation (10%) and from those who were not working any more, their last occupation (80%) was used. A classification according to occupation could be made for 91%. This classification, based on the international Erikson-Goldthorpe-Portocarero (EGP) scheme,[20,21] distinguishes five levels: higher and lower grade professionals; routine non-manual employees; small proprietors; high and low skilled manual workers; semiskilled and unskilled manual workers.

In addition to a woman's own occupation, the occupation of the head of the household provides in some cases a better reference point and was also assessed. Both perspectives have their validity and there is no clear preference for either one.[22] For each woman who was living with a partner or was widowed, her partner was assumed to be the head of the household. Among the elderly population in The Netherlands this is a plausible assumption. For the other women, divorced or living without a partner, the woman herself was considered to be head of the household. The classification of occupation of the head of the household was done in a similar way as for individual occupation and was available for 89% of the female participants.

Income Participants classified their household income in 13 pre-coded categories. For persons living in an elderly home some persons gave their factual income, while others indicated just their 'pocket money' (their income minus the contribution for the rate of living in an elderly home). For this reason, those living in an elderly home (n=897) were excluded from the analysis of income.

As in some households more than one person is dependent on the household income, the midpoint of each household income category was divided by the number of persons who were living from that income to the power 0.36.[23] The result of this formula provides what is called the 'equivalent household income'. Five categories of equivalent household income were defined (see Table 3.1.1), corresponding approximately to quintiles of the distribution of the population. Equivalent household income was available for 89% of the independently living people.

Mortality Information about the vital status was collected from the start of follow-up until July 1st, 1996 from the municipal population registry, from hospital admission data, and from computer systems of the general practitioners of the district. In addition, information was retrieved from medical records of participants of general practitioners not linked to this computer system, for instance from participants who moved out our research district. The individual period of the follow-up was defined as the period between the first home interview until July 1st, 1996 or until date of death. During an average follow-up period of 4.1 years (SD 1.3), 793 women (16%) and 528 men (17%) died.

Table 3.1.1 Characteristics of the study population.

	Men	Women	
Age in %	*n=3,105*	*n=4,878*	
55 - 59 years	16.5	14.7	
60 - 64 years	20.9	17.2	
65 - 69 years	21.1	15.6	
70 - 74 years	16.8	15.7	
75 - 79 years	12.5	13.2	
80 - 84 years	7.4	10.6	
85 - 89 years	3.6	8.3	
90 years and older	1.3	4.6	
Marital status in %	*n=2,662*	*n=4,375*	
No partner	2.6	7.6	
With partner	83.7	50.8	
Widowed	10.4	35.6	
Divorced	3.3	6.0	
Living situation in %	*n=3,105*	*n=4,878*	
Independent	94.0	85.4	
In a home for elderly	6.0	14.6	
Education in %	*n=3,017*	*n=4,552*	
Higher vocational education and university	14.5	4.0	
Higher general and intermediate vocational education	35.1	19.2	
Lower/intermediate general and lower vocational education	22.5	28.5	
Primary education	27.9	48.3	
	Own	*Own*	*Head of household*
Occupation in %	*n=2,975*	*n=4,257*	*n=4,350*
Professionals	33.3	10.8	27.6
Routine non-manual employees	25.8	43.1	28.5
Small proprietors	5.1	3.6	5.8
High and low skilled manual workers	21.6	2.3	19.0
Semiskilled and unskilled manual workers	14.2	40.3	19.1
Equivalent household income in %	*n=2,609*	*n=3,701*	
> 1,667 US$	25.9	15.1	
> 1,284 US$ - ≤ 1,667 US$	26.4	20.4	
> 1, 021 US$ - ≤ 1,284 US$	21.7	19.1	
> 706 US$ - ≤ 1,021 US$	16.1	18.4	
≤ 706 US$	9.9	27.0	

Data analysis

Relative risks of mortality by the indicators of socioeconomic status were estimated using the Cox' proportional hazard regression model. Separate age-adjusted analyses (nine 5-year age groups) were performed for men and women. Indicators of socioeconomic status were included in the model as dummy variables, while for all indicators the 'highest' socioeconomic status was used as the reference group.

Furthermore, simultaneous analyses with indicators of socioeconomic status included in a model were performed. The reduction in deviance owing to inclusion of a second or third indicator of socioeconomic status in the model was used as an overall statistical test. A 5-year survival probability was calculated using the formula $S(t)=S_0(t)^{\exp(\Sigma \beta \cdot X)}$.

To assess modification of risk by age, interaction terms of socioeconomic status and age were included in the model. Again, the reduction in deviance was used as a statistical overall test. All analyses were performed using the BMDP-package.[24]

3.1.4 Results

The general characteristics of the study population are shown in Table 3.1.1. The population comprised more women than men and the average age in women was higher, 72 (SD 10) and 69 (9) years respectively. The majority, 84% of the men and 51% of the women, was living with a partner. Furthermore, the proportion of widowed or divorced women was higher than the proportion of widowed or divorced men. In general, the indicators of socioeconomic status were distributed unequally for men and women. For instance, the average equivalent household income of men was higher than the equivalent household income of women. Of the men, 28% had only primary education while this percentage was 48% for women. Women were more likely to be classified, based on their own occupation, as a manual worker and were less likely to be classified as a professional.

In Table 3.1.2 to Table 3.1.4 mortality data are given by indicators of socioeconomic status. For men as well as women, the lower educated had a significantly higher mortality risk than those who had higher vocational education or university. The gradient for women was steeper than for men, probably due to a more selected reference group. Mortality differences between the occupational classes were less pronounced in the older population. In men, only the semiskilled and unskilled manual workers had a significantly higher mortality risk than the male professionals. For women, neither their own occupation nor the occupation of the head of the household was related to mortality. Equivalent household income was related to mortality among men. In the lower quintiles of equivalent household income mortality was almost twice as high as in the highest quintile. For women, less pronounced differences were found.

Results of simultaneous analyses with three indicators of socioeconomic status are presented in Table 3.1.5. These analyses were based on a subgroup of 2,517 men and

Table 3.1.2 Mortality by education, relative risks and 95% confidence intervals, adjusted for age.

	Men			Women		
Education level	N	RR	95%-CI	N	RR	95%-CI
Higher vocational education and university	11	1		38	1	
Higher general and intermediate vocational education	153	1.4	0.9-1.9	71	1.7	0.9-3.2
Lower/intermediate general and lower vocational education	92	1.2	0.8-1.8	120	1.8	1.0-3.3
Primary education	199	1.4	1.0-2.0	403	2.0	1.1-3.6

RR Relative risk.
CI Confidence interval.
N Number of deaths.

Table 3.1.3 Mortality by occupation, relative risks and 95% confidence intervals, adjusted for age.

	Men			Women					
	Own			Own			Head of household		
Occupation	N	RR	95%-CI	N	RR	95%-CI	N	RR	95%-CI
Professionals	119	1		46	1		122	1	
Routine non-manual employees	119	1.1	0.9-1.4	191	1.2	0.8-1.6	161	1.0	0.8-1.3
Small entrepreneurs	32	1.1	0.8-1.7	22	1.1	0.7-1.8	44	0.9	0.7-1.3
High/low skilled manual workers	120	1.1	0.9-1.4	20	1.4	0.8-2.4	117	1.0	0.8-1.3
Semi-/unskilled manual workers	93	1.4	1.0-1.8	271	1.2	0.9-1.6	140	0.9	0.7-1.2

RR Relative risk.
CI Confidence interval.
N Number of deaths.

Table 3.1.4 Mortality by equivalent household income, relative risks and 95% confidence intervals, adjusted for age.

	Men			Women		
Equivalent household income	N	RR	95%-CI	N	RR	95%-CI
> 1,667 US$	44	1		21	1	
> 1,284 US$ - ≤ 1,667 US$	69	1.3	0.9-1.8	41	1.0	0.6-1.8
> 1,021 US$ - ≤ 1,284 US$	97	1.7	1.2-2.5	55	1.2	0.7-1.9
> 706 US$- ≤ 1,021 US$	89	1.8	1.2-2.6	66	1.1	0.7-1.8
≤ 706 US$	66	1.7	1.1-2.5	120	1.2	0.7-2.0

RR Relative risk.
CI Confidence interval.
N Number of deaths.

3,402 women for whom data on education, own occupation and equivalent household income were available. As the relative risks decreased when adjusted for each other and the reduction of deviance owing to inclusion of each indicator to a model with the two other indicators was not statistically significant, the three indicators share some overlap. Despite this overlap, differences in mortality by equivalent household income and education for men persisted suggesting that these indicators reflect different dimensions of socioeconomic status. Only the effect of equivalent household income remained statistically significant. For women, all reductions in deviance owing to inclusion of other indicators were not statistically significant. The relative risks declined after adjustment for the other indicators in the model and did not remain significant.

Table 3.1.5 Mortality by education, own occupation and equivalent household income simultaneously, relative risks and 95% confidence intervals, adjusted for age.

	Men *(n=2,517)*		Women *(n=3,402)*	
Indicators of socioeconomic status	RR	95%-CI	RR	95%-CI
Reference group				
Higher vocational education or university, professional and highest quintile of equivalent household income	1			
Education				
Higher general and intermediate vocational education	1.3	0.8-2.0	1.5	0.6-3.7
Lower mediate general and vocational education	1.2	0.7-1.9	1.7	0.8-4.0
Primary education	1.3	0.8-2.0	1.5	0.8-3.7
Own occupation				
Routine non-manual employees	1.0	0.8-1.4	1.0	0.6-1.6
Small entrepreneurs	1.2	0.7-2.0	0.7	0.3-1.8
High and low skilled manual workers	0.8	0.6-1.1	0.6	0.2-1.7
Semiskilled and unskilled manual workers	1.0	0.7-1.5	1.0	0.6-1.6
Equivalent household income				
> 1,284 US$ - ≤ 1,667 US$	1.3	0.8-1.9	1.0	0.6-1.7
> 1,021 US$ - ≤ 1,284 US$	1.8	1.2-2.7	1.1	0.6-1.9
> 706 US$ - ≤ 1021 US$	1.7	1.1-2.7	1.0	0.6-1.7
≤ 706 US$	1.8	1.1-2.8	1.0	0.6-1.8

RR Relative risk.

CI Confidence interval.

To illustrate the differences in mortality risk between the most privileged and most underprivileged persons, the predicted 5-year survival was calculated for a 65-year-old unskilled man, with primary education only and an equivalent household income below 706 US$ (*f*1,210) and for a 65-year-old professional, with an academic degree and an equivalent household income above 1,667 US$ (*f*2,850). The estimated absolute difference in 5-year survival was 9%. The man with the highest socioeconomic status had a 5-year survival probability of 93%, while this probability was 84% for the man with the lowest socioeconomic status.

Whether the effects of socioeconomic differences attenuate with age, could not be confirmed in this study. Age stratified analyses did not show clear patterns (results not shown) and the interaction terms for each socioeconomic indicator and age in the model were not statistically significant.

3.1.5 Discussion

This study shows differences in mortality risks for older men by all three indicators of socioeconomic status: income, occupation and education. Mortality is higher for lower educated men, unskilled manual workers and those with a lower income compared to the higher socioeconomic status groups. For women in this age group mortality is higher in the lower educated groups, but lower income and occupational level appeared not to be related to mortality. These educational differences among women remained, (though not statistically significant) after adjustment for the other indicators. For men, the effect of income on mortality remained after adjustment for the other indicators of socioeconomic status.

To appreciate these findings, some issues need to be addressed. The response rate for the study was high. Still, it is likely that the population represents a relatively healthy cohort as persons with health problems are less able to participate in the follow-up study.[25,26] In our view this selective participation has hardly influenced the results or, if anything, it has led to an underestimation of the real differences. Also, exclusion of persons living in an elderly home for the analyses of income might have led to an underestimation of the mortality risk associated with a low equivalent household income. However, the educational and occupational mortality differences among independently living persons did not substantially differ from those living in an elderly home (results not shown).

Information bias with respect to socioeconomic status was minimised by gathering information on socioeconomic status in a standardised way. Some misclassification for occupation may have occurred for persons who stopped working a long time ago, as the classification used is quite recent, while the status of a certain occupation may not have been constant over time and the occupation structure within a society is changing.[27] In which direction this might have affected the results is unclear. Furthermore, it has been argued that the last or current occupation does not reflect the occupational status accurately, but no commonly accepted alternative method has gained favour.[22] In our data, however, a person's longest held occupation did not substantially differ from the last or current occupation, which confirms other Dutch findings that intragenerational mobility is limited.[27] Additional analyses based on the longest held occupation showed the same mortality differences as the last or current occupation (results not shown). A measure of income that takes into account the size of the household is generally regarded to be more appropriate than just the household income.[22] The choice of the factor 0.36 in the formula was based on published analyses,[23] but remains quite arbitrary. However, when a factor 0.50 or 0.25 was used instead, the same trends resulted (results not shown).

Our results were analysed separately for men and women and adjusted for age, as among the younger age groups of our population more persons attained higher education than among the older. In some studies the results have also been adjusted for marital status. However, one can argue that marital status not only is a confounder but also an intermediary factor, because marital status can be predicted by the socioeconomic status.[28] In such case adjustment for marital status may actually introduce bias.[29] In any case, in our study adjustment of marital status did not give substantially different results. In our view, there is no reason to assume that bias could explain the socioeconomic mortality differences found.

In our study, the study population was chosen in one quite homogenous region. The situation occurs that several intermediary factors, such as neighbourhood conditions, housing conditions or health care services are similar for everybody. Since these macrofactors also account for the socioeconomic inequalities in health in the total population,[30,31] part of the socioeconomic differences in health may not be detected in such a setting. The inequalities in mortality would probably be even larger when the socioeconomic groups vary also in these intermediary factors.

Socioeconomic mortality differences were studied in several countries and generally show the same trends as we observed by us.[1-6] Studies on socioeconomic mortality differences among elderly people are more limited in number, but have shown differences according to education in the United States,[12] according to social class in England and Wales[32] and in Swedish elderly people[16] and according to several indicators of socioeconomic status in Finnish elderly people.[13] This limited number of studies among ageing populations have shown the same associations as found in our study.

Reported findings on whether socioeconomic differences in mortality increase or decrease with age are inconsistent. Martelin reported that the differentials attenuate with age.[13] In contrast, a Swedish study reported an increasing difference with increasing age for women, while for men the differences became smaller.[16] However, in the latter study, no formal test of significance was applied to these differences. Among British civil servants socioeconomic differences in mortality persisted beyond retirement age and in magnitude increased with age.[11] Our study did not show a clear pattern of changes with age. The follow-up period, however, was relatively short and the number of subjects may be too limited.

Interestingly, in contrast to one previous Dutch study of a 25-year follow-up among middle-aged men,[2] in which mortality differences according to occupational class disappeared at an age above 50, we found socioeconomic mortality differences in an older age group.

As a direct effect of socioeconomic status on mortality is not very likely, health related social mobility and intermediary factors are mentioned in the literature as possible explanations for socioeconomic mortality differences.[33] Health related social mobility implies that people drift down the social scale because of their health problems or move up because of their good health. In this respect, Fox[32] suggested that a measure representing the situation of years ago, would provide a more appropriate indicator of socioeconomic status than a measure which would be measured at death. In our study, most persons completed their education decades ago and had stopped working many years previously. Furthermore, although the measurement of income is based on the current situation, among Dutch elderly people it is not likely to be influenced by health. Hence, health selection is not likely to be important in the explanation of the socioeconomic differences that we found. The remaining mechanism is an explanation through intermediary factors, such as life style factors, material living conditions and psychological stress. The unequal distribution of these factors across groups of different socioeconomic status may explain the socioeconomic mortality differences and needs further investigation.

Besides specific factors which are responsible for the socioeconomic inequalities in specific diseases, an additional explanation for the socioeconomic differences in health has been suggested: socioeconomic status is associated with factors that influence someone's general susceptibility to diseases.[34]

The apparent differences in impact between the different indicators as found in our study may have several explanations. First, the overlap of the indicators of socioeconomic status in this study population is less pronounced compared to other studies.[35] In our study the Spearman rank correlation coefficients vary between 0.23 and 0.47. Thus, the causal pathway of education as an important determinant of occupational status, and occupation as a determinant of income, is less pronounced among this elderly population. Second, these indicators represent different aspects of socioeconomic status.[22] Educational level indicates someone's knowledge, ability and willingness to acquire new information. Occupation stands for prestige and occupational hazards and income indicates material living conditions and resources. Each indicator could be associated with different intermediary factors, which could then explain the differences in association with mortality. Thus, our findings among men suggest that material living conditions are important in the explanation of socioeconomic mortality differences. However, an alternative explanation for the differences in impact for the different socioeconomic indicators is also possible. In our study population, the indicators 'education' and 'occupation' are based on an individual achievement of years ago and will have been constant for years. Income on the other hand may have changed even recently and may be a more accurate indicator of current socioeconomic status. If current socioeconomic status is more important to health than past socioeconomic status, this might explain the greater discriminating power of income. The lack of finding such an association among women, might be caused by misclassification of income; it is likely that women have reported their household income less accurate, as it is mainly based on their husbands.

In conclusion, our results show that mortality differences by socioeconomic status persist into old age. The mechanisms to explain these inequalities in health among older subjects require further research.

3.1.6 References

1. Doornbos G, Kromhout D. Educational level and mortality in a 32-year follow-up study of 18-year-old men in The Netherlands. *Int J Epidemiol* 1990;19:374-9.
2. Duijkers TJ, Kromhout D, Spruit IP, Doornbos G. Inter-mediating risk factors in the relation between socioeconomic status and 25-year mortality (the Zutphen Study). *Int J Epidemiol* 1989;18:658-62.
3. Fox AJ, Goldblatt PO, Jones DR. Social class mortality differentials: artefact, selection or life circumstances? *J Epidemiol Community Health* 1985;39:1-8.
4. Holme I, Helgeland A, Hjermann I, Leren P, Lund-Larsen PG. Four-year mortality by some socioeconomic indicators: the Oslo study. *J Epidemiol Community Health* 1980;34:48-52.
5. Marmot MG, McDowall ME. Mortality decline and widening social inequalities. *Lancet* 1986;2:274-6.
6. Marmot MG, Shipley MJ, Rose G. Inequalities in death--specific explanations of a general pattern? *Lancet* 1984;1:1003-6.
7. Mackenbach JP, Kunst AE, Cavelaars AE, Groenhof F, Geurts JJ. Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet* 1997;349:1655-9.
8. Olshansky SJ, Ault AB. The fourth stage of the epidemiologic transition: the age of delayed degenerative diseases. *Milbank Q* 1986;64:355-91.
9. Jefferys M. Social inequalities in health--do they diminish with age? *Am J Public Health* 1996;86:474-5.

10. Thorslund M, Lundberg O. Health and Inequalities among the oldest old. *J Aging Health* 1994;6:51-69.

11. Marmot MG, Shipley MJ. Do socioeconomic differences in mortality persist after retirement? 25 year follow up of civil servants from the first Whitehall study. *BMJ* 1996;313:1177-80.

12. Feldman JJ, Makuc DM, Kleinman JC, Cornoni-Huntley J. National trends in educational differentials in mortality. *Am J Epidemiol* 1989;129:919-33.

13. Martelin T. Mortality by indicators of socioeconomic status among the Finnish elderly. *Soc Sci Med* 1994;38:1257-78.

14. Moore DE, Hayward MD. Occupational careers and mortality of elderly men. *Demography* 1990;27:31-53.

15. Mossey JM, Shapiro E. Self-rated health: a predictor of mortality among the elderly. *Am J Public Health* 1982;72:800-8.

16. Otterblad Olausson P. Mortality among the elderly in Sweden by social class. *Soc Sci Med* 1991;32:437-40.

17. Valkonen T. Problems in the measurement and international comparisons of socio-economic differences in mortality. *Soc Sci Med* 1993;36:409-18.

18. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

19. Unesco. *International Standard Classification of Education (ISCED).* Paris, 1976.

20. Erikson E, Goldthorpe JH. *The constant flux.* Oxford: Clarendon Press, 1992.

21. Ganzeboom HBG, Luijkx R, Treiman DJ. Intergenerational class mobility in comparative perspective. *Res Social Stratification Mobility* 1989;8:3-84.

22. Liberatos P, Link BG, Kelsey JL. The measurement of social class in epidemiology. *Epidemiol Rev* 1988;10:87-121.

23. Buhmann B, Rainwater L, Schmaus G, Smeeding TM. Equivalence scales, well-being, inequality, and poverty: sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) data base. *Review of Income and Wealth* 1988;2:115-42.

24. Dixon WJ, ed. *BMDP Statistical Software Manual.* Berkeley: University of California Press, 1990.

25. Herzog AR, Rodgers WL. Age and response rates to interview sample surveys. *J Gerontol* 1988;43:S200-5.

26. Kelsey JL, O'Brien LA, Grisso JA, Hoffman S. Issues in carrying out epidemiologic research in the elderly. *Am J Epidemiol* 1989;130:857-66.

27. Dronkers J, Ultee WC, ed. *Verschuivende ongelijkheid in Nederland. Sociale gelaagdheid en mobiliteit [in Dutch].* Assen: Van Gorcum, 1995:335.

28. Collins R, Coltrane S. *Sociology of marriage and the family: gender, love and property* Chigago: Nelson Hall Inc., 1992.

29. Robins J. The control of confounding by intermediate variables. *Stat Med* 1989;8:679-701.

30. Stronks K. *Socio-economic inequalities in health: individual choice or social circumstances?* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1997.

31. Kaplan GA. Where do shared pathways lead? Some reflections on a research agenda. *Psychosom Med* 1995;57:208-12.

32. Fox AJ. Socio-economic differences in mortality and morbidity. *Scand J Soc Med* 1990;18:1-8.

33. Townsend P, Davidson N, Whitehead M, ed. *Inequalities in health (The Black Report & The health Divide).* London: Penguin Books, 1988.

34. Marmot MG, Rose G, Shipley M, Hamilton PJ. Employment grade and coronary heart disease in British civil servants. *J Epidemiol Community Health* 1978;32:244-9.

35. Abramson JH, Gofin R, Habib J, Pridan H, Gofin J. Indicators of social class. A comparative appraisal of measures for use in epidemiological studies. *Soc Sci Med* 1982;16:1739-46.

3.2 Employment grade differences in cause specific mortality between middle-aged and elderly men. The first Whitehall Study

3.2.1 Abstract

Study objective. To test the hypothesis that the association between socioeconomic status and mortality rates cuts across the major causes of death for middle-aged and elderly men.

Design. 25-year follow-up of mortality in relation to employment grade.

Setting. The first Whitehall Study.

Participants. 18,001 male civil servants aged 40-69 years who attended the initial screening between 1967 and 1970 and were followed up for at least 25 years.

Main outcome measure. Specific causes of death.

Results. After more than 25-years of follow-up of civil servants, aged 40-69 years at entry to the study, employment grade differences still exist in all cause mortality and for nearly all specific causes of death. Main risk factors could only explain one third of this gradient. Comparing the older retired group with the younger pre-retirement group, the differentials in mortality remained but were less pronounced. The largest decline was seen for chronic bronchitis, gastrointestinal diseases and genito-urinary diseases.

Conclusions. Differentials in mortality persist at older ages for almost all causes of death.

3.2.2 Introduction

An association between socioeconomic status and mortality has been shown in several studies and countries.[1-5] Marmot et al suggested that there was a general susceptibility to specific causes of death, since after a 10-year follow-up of British civil servants in the first Whitehall Study an inverse gradient by employment grade was seen for most causes of death.[6] However, the number of events used in this analysis was relatively small. After 25 years of follow-up of this study population, it is possible to examine these associations again with many more events. Furthermore, it was possible to examine the diversity in the gradients by causes of death and to examine even more specific causes of death.

In addition, we might expect these socioeconomic differences to be less pronounced in old age, as the eventual probability of death for each person reaches 100%. However, social class differentials in mortality are still found in these age groups.[7-10] A previous analysis of the 25-year follow-up data from the first Whitehall Study has shown that relative differences in mortality between socioeconomic groups decrease but still persist beyond retirement age and in absolute terms even increase with old age.[11] The question arises whether this applies to different causes of death to the same extent or whether there are some causes where the grade effects disappear after retirement age. Therefore, we have examined whether the employment grade effects decreased with more years of follow-up and whether these associations differ between middle-aged men and older retired men.

3.2.3 Subjects and methods

Methods

A total of 19,019 civil servants aged 40-69 years attended the initial screening of the Whitehall Study between September 1967 and January 1970. In short, each participant filled in a standard questionnaire that included age, self-reported smoking habit, civil servants' employment grade, and health status. Measurements at the screening examination included blood pressure, plasma cholesterol concentration and a glucose tolerance test. Subjects with a blood glucose, two hours after a post-fasting 50g glucose load, above 11.1 mmol/L or with previously diagnosed diabetes constituted the diabetic group; non-diabetic subjects with glucose concentrations above the 95th centile point (5.4-11.0 mmol/L) formed the group with impaired glucose tolerance, and other subjects were designated as being normoglycaemic. Smoking has been categorised according to cigarette use as current smokers, ex-smoker and never smoker. More details regarding design and methods are described elsewhere.[12] Employment grade was categorised as administrative, professional and executive, clerical, and 'other' grades (e.g. messengers and other unskilled manual workers). For 886 men from the Diplomatic Service and the British Council, employment grade was not comparable with the grades above and these men have been excluded from the analyses.

Records from 99.3% of the remaining men were flagged at the National Health Service Central Registry, which notified us of all deaths up to the end of January 1995. Causes were classified according to the International Classification of Disease, eighth revision (ICD-8). A total of 18,001 men were followed up for at least 25 years and contributed a total of 385,660 person-years with 8,053 deaths. For another 21 subjects the cause of death was missing, these have been excluded from the cause specific mortality analysis.

Data analysis

Mortality rates have been calculated using person-years at risk. These rates have been standardised for age at entry by the direct method, using 5-year age bands and with the total population as the standard. The mortality gradients across the four employment grades are close to linear. Therefore, to compare the trends across the employment grade levels between several causes of death we estimated the rate ratio between the lowest and the highest employment grade using Cox' proportional hazard models in which employment grade was added as a continuous variable. We estimated the rate ratio between the highest (i.e. administrative) and the lowest employment grade (i.e. 'others') by taking the exponent of three times the coefficient for employment grade. This method has the advantage of giving a more stable estimate since all the data, rather just the data from the relatively small groups of the 'other' grade and administrative grade, are used.

In several previous analyses, socioeconomic differences have been partly explained by the biological and behavioural factors of smoking, blood pressure and cholesterol.[2,5,13] To examine the impact of these risk factors on these employment grade differences, mortality rate ratios among subjects who are not currently smoking and who have a low plasma cholesterol level (below the median of 5.0 mmol/L) and a low systolic blood pressure (below 133 mmHg) were estimated. In addition, the mortality rate ratios based on the whole population were adjusted for several risk factors: smoking, systolic blood pressure, glucose intolerance and diabetes, and cholesterol.

To compare the employment grade differences for three different intervals of follow-up, we split our data set into three parts and computed age-adjusted rate ratios for the four employment grades taking the professional/executive as the reference group since the administrative grade had relatively small numbers.

For the analysis of the age specific mortality differentials we created also a new expanded data set in which for each individual year of follow-up a new record was created, consisting of each man's current age at risk together with his employment grade and length of follow-up in that year. Deaths were allocated to the appropriate current age category. This data set was split into three parts depending on the subject's current age. As men at lower risk of death had on average, a longer follow-up, we adjusted these analyses for the length of follow-up and also adjusted for age using 5-year age groups. All analyses were done using the statistical package SAS.[14]

3.2.4 Results

Table 3.2.1 shows the age adjusted mortality rates by employment grade and the rate ratio of the lowest versus the highest employment grade for all the broad major causes of death after more than 25 years of follow-up. The mortality rate was higher for all these major causes of death in the lower grades compared to the higher grades and was statistically significant in almost all cases. The largest differences were found for lung cancer, chronic bronchitis and respiratory diseases. Looking at the differences in absolute rates, cardiovascular disease and neoplasms contributed the largest part to the differences between the mortality rates by grade.

For some groups of diseases, for example 'other neoplasms', the weak association was caused by the heterogeneity between the diseases within the group. In a previous analysis in this study population, Davey Smith et al examined the heterogeneity of the relationships between specific cancer sites and socioeconomic position.[15] There seemed to be a considerable variation in the strength, and, to a lesser extent, direction of the associations between those specific cancer sites and employment grade.[15] This heterogeneity between specific cancer sites was also seen in the present 25-year mortality

Table 3.2.1 Age adjusted mortality rates per 1000 person-years (number of deaths) by employment grade and mortality rate ratios for 'other' grade versus administrative.*

Causes of death (ICD-8)	Mortality rates (Number of deaths) Administrative *(n=962)*	Professional/ Executive *(n=12,269)*	Clerical *(n=2,981)*	Other *(n=1,789)*	Mortality rate ratio (95%-CI) 'Other' grade versus Administrative
All causes	16.76 (295)	20.74 (4,733)	27.43 (1,779)	30.91 (1,246)	2.07 (1.90-2.25)
Malignant neoplasm of lung (162.1)	0.76 (16)	1.53 (358)	2.80 (181)	3.28 (147)	4.08 (3.10-5.38)
Other neoplasms (140-239, excl. 162.1)	4.00 (72)	4.57 (1,088)	4.94 (313)	5.53 (207)	1.43 (1.17-1.74)
Ischaemic heart disease (410-414)	6.41 (105)	7.29 (1,679)	9.10 (583)	10.07 (394	1.77 (1.53-2.06)
Cerebrovascular disease (430-438)	1.43 (26)	1.79 (380)	2.12 (144)	1.81 (81)	1.35 (0.99-1.85)
Other cardiovascular (390-404,420-429,440-458)	1.18 (23)	1.73 (385)	2.42 (160)	2.38 (104)	2.13 (1.59-2.86)
Chronic bronchitis (491-492)	0.10 (2)	0.23 (44))	0.77 (51)	1.14 (48)	10.76 (5.96-19.42)
Other respiratory disease (460-490,493-519)	1.10 (20)	1.59 (337)	2.82 (192)	3.68 (155	4.13 (3.15-5.43)
Gastrointestinal disease (520-577)	0.66 (8)	0.41 (94)	0.54 (37)	0.88 (30)	2.42 (1.35-4.36)
Genito-urinary disease (580-607)	0.25 (4)	0.26 (53)	0.31 (20)	0.51 (25)	3.27 (1.59-6.71)
Accident and violence (800-949,960-978)	0.13 (3)	0.20 (51)	0.28 (16)	0.36 (11)	2.38 (0.98-5.78)
Suicide (950-958,980-989)	0.10 (2)	0.17 (45)	0.25 (15)	0.21 (6)	1.65 (0.60-4.50)
Other deaths	0.57 (11)	0.93 (207)	1.05 (63)	0.97 (36)	1.43 (0.91-2.24)
Causes not related to smoking†					
Neoplasms	2.74 (53)	2.92 (690)	3.12 (194)	3.16 (114)	1.19 (0.92-1.54)
Non-neoplasms	5.54 (100)	7.12 (1,564)	9.83 (651)	10.91 (450)	2.25 (1.95-2.60)

* Based on exponent of three times the coefficient of employment grade assessed with Cox' proportional hazard models, in which employment grade is added as a continuous variable.

CI Confidence interval.

† All causes less 140-141, 143, 149, 150, 157, 160-163, 188-189, 200, 202, 410-414, 491, 492.

Table 3.2.2 Age adjusted mortality rates per 1000 person-years (number of deaths) by employment grade and mortality rate ratios for 'other' grade versus administrative for diseases of the circulatory system.

Causes of death (ICD-8)	Mortality rates (Number of deaths)				Mortality rate ratio *(95%-CI)* 'Other' grade versus Administrative
	Administrative *(n=962)*	Professional/ Executive *(n=12,269)*	Clerical *(n=2,981)*	Other *(n=1,789)*	
Ischaemic heart disease (410-414)	6.41 (105)	7.29 (1,676)	9.10 (583)	10.07 (394)	1.77 (1.53-2.06)
Acute myocardial infarction (410)	4.15 (66)	5.07 (1,177)	6.27 (398)	7.48 (286)	1.85 (1.55-2.20)
Chronic ischaemic heart disease (412)	2.18 (37)	2.14 (486)	2.70 (177)	2.44 (103)	1.59 (1.21-2.11)
Cerebrovascular disease (430-438)	1.43 (26)	1.79 (380)	2.12 (144)	1.81 (81)	1.35 (0.99-1.85)
Other cardiovascular (390-404,420-429,440-458)	1.18 (23)	1.73 (385)	2.42 (160)	2.38 (104)	2.13 (1.59-2.86)
Active rheumatic fever and chronic rheumatic heart disease (390-399)	0.11 (3)	0.16 (34)	0.25 (15)	0.24 (11)	2.65 (1.03-6.84)
Hypertensive disease (400-404)	0.06 (1)	0.15 (36)	0.19 (12)	0.20 (10)	2.44 (0.92-6.51)
Other forms of heart disease (420-429)	0.25 (5)	0.46 (100)	0.70 (46)	0.60 (28)	2.13 (1.21-3.74)
Diseases of arteries, arterioles and capillaries (440-447)	0.45 (8)	0.69 (152)	0.92 (63)	1.08 (43)	2.24 (1.41-3.57)
Aortic aneurysm (441)	0.24 (4)	0.53 (118)	0.68 (45)	0.86 (34)	2.52 (1.48-4.30)
Diseases of veins and lymphatics and other diseases of circulatory system (450-458)	0.16 (3)	0.40 (37)	0.22 (15)	0.14 (7)	1.76 (0.64-4.87)

CI Confidence interval.

Table 3.2.3 Age adjusted mortality rate ratios for 'other' grade versus administrative for non-smokers with a low cholesterol and low systolic blood pressure and mortality rate ratios, adjusted for age and risk factors, for the whole population.

	Non-smokers with low plasma cholesterol and low blood pressure* *(n=2,376)*		Whole population *(n=18,001)*
Causes of death (ICD-8)	Number of deaths	Mortality rate ratio *(95%-CI)* adjusted for age; 'Other' grade versus Administrative	Mortality rate ratio *(95%-CI)* adjusted for age and risk factors†, 'Other' grade versus Administrative
All causes	614	2.30 (1.54-3.43)	1.75 (1.60-1.91)
Malignant neoplasm of lung (162.1)	38	0.59 (0.12-2.96)	2.75 (2.09-3.63)
Other neoplasm (140-239 excl. 162.1)	184	1.28 (0.65-2.50)	1.36 (1.11-1.66)
Ischaemic heart disease (410-414)	173	2.61 (1.39-4.89)	1.52 (1.24-1.86)
Cerebrovascular disease (430-438)	38	1.51 (0.38-6.03)	1.11 (0.81-1.53)
Other cardiovascular (390-404,420-429,440-458)	44	4.37 (1.25-15.28)	1.66 (1.23-2.24)
Chronic bronchitis (491-492)	9	‡	6.53 (3.59-11.87)
Other respiratory disease (460-490,493-519)	52	11.09 (3.59-34.39)	2.98 (2.26-3.93)
Gastrointestinal disease (520-577)	19	‡	1.93 (1.07-3.49)
Genito-urinary disease (580-607)	10	‡	2.61 (1.25-5.46)
Accident and violence (800-949,960-978)	9	‡	2.47 (1.00-6.10)
Suicide (950-958,980-989)	4	‡	1.20 (0.43-3.37)
Other deaths	32	3.40 (0.78-14.68)	1.24 (0.78-1.97)

* Non-smokers (never and ex-smokers) with cholesterol and systolic blood pressure values below the median; Cholesterol <5.0 mmol/L; Systolic blood pressure <133 mmHg.

CI Confidence interval.

† Adjusted for age, smoking, systolic blood pressure, plasma cholesterol concentration and glucose intolerance.

‡ Mortality rate ratio not estimated for causes of death with less than 20 deaths.

results (test for heterogeneity; $P < 0.01$). Socioeconomic differentials for subcategories of cardiovascular disease are reported in Table 3.2.2. In contrast to the heterogeneous effects across cancer sites, the socioeconomic differentials in diseases of the circulatory system were quite homogeneous with rate ratios varying between 1.35 and 2.65.

In previous analyses, employment grade differences have been partly explained by the biological and behavioural factors of smoking, blood pressure and cholesterol.[2,5,13] The question arises whether employment grade differences exist among subjects who are not currently smoking and who have a low plasma cholesterol level and a low blood pressure. Table 3.2.3 shows these grade differences in mortality for this low-risk group. The estimated mortality rate ratio is not given for those causes with fewer than 20 deaths. Even in this low-risk group an employment gradient is seen in all cause mortality. Only 38 of the 702 of the lung cancer deaths occurred in this non-smoking subgroup. For most other specific causes of death the employment grade gradients are even steeper in this low-risk group compared to those in the whole study population. Furthermore, mortality rate ratios which are adjusted for age and the major risk factors and based on the whole population are shown in Table 3.2.3. Adjustment for these risk factors reduced the employment grade differences for almost all specific causes of death. About one third of the employment grade differences in all cause mortality could be explained by these differences in risk factors.

The 25-year follow-up gave us the opportunity to examine whether the mortality rate ratios with employment grade were the same after different intervals of follow-up. Figure 3.2.1 shows the rate ratios for total and cause specific mortality after the first 10 years of follow-up, the second 10 years of follow-up and for the follow-up after 20 years. In general, the differentials in mortality decreased slightly, after more years of follow-up. However, the employment grade differences in mortality persisted even after more than 20 years of follow-up.

To examine the differentials in mortality, pre- and post-retirement, we calculated the employment grade differences in mortality by three age groups and adjusted for the length of follow-up. Table 3.2.4 shows the rate ratios for the 'other' versus administrative grade by the three age groups. In the older age groups a smaller proportion of deaths were caused by ischaemic heart diseases, but this was compensated by greater proportions due to cerebrovascular disease, other cardiovascular disease and other respiratory diseases. In all three age groups, a gradient was seen between employment grade and all cause mortality and most specific causes of death. In general, the associations in the youngest age group were steeper than in the higher age groups. The rate ratios for employment grade in those men aged 65-69 years were not always significant owing to the small numbers of deaths. The steepest decrease in gradient with increased age was seen

Figure 3.2.1 Age adjusted mortality rate ratios (with the professional/executive grade used as the reference group) by employment grade and three periods of follow-up: 0-9 years, 10-19 years and 20-27 years of follow-up.

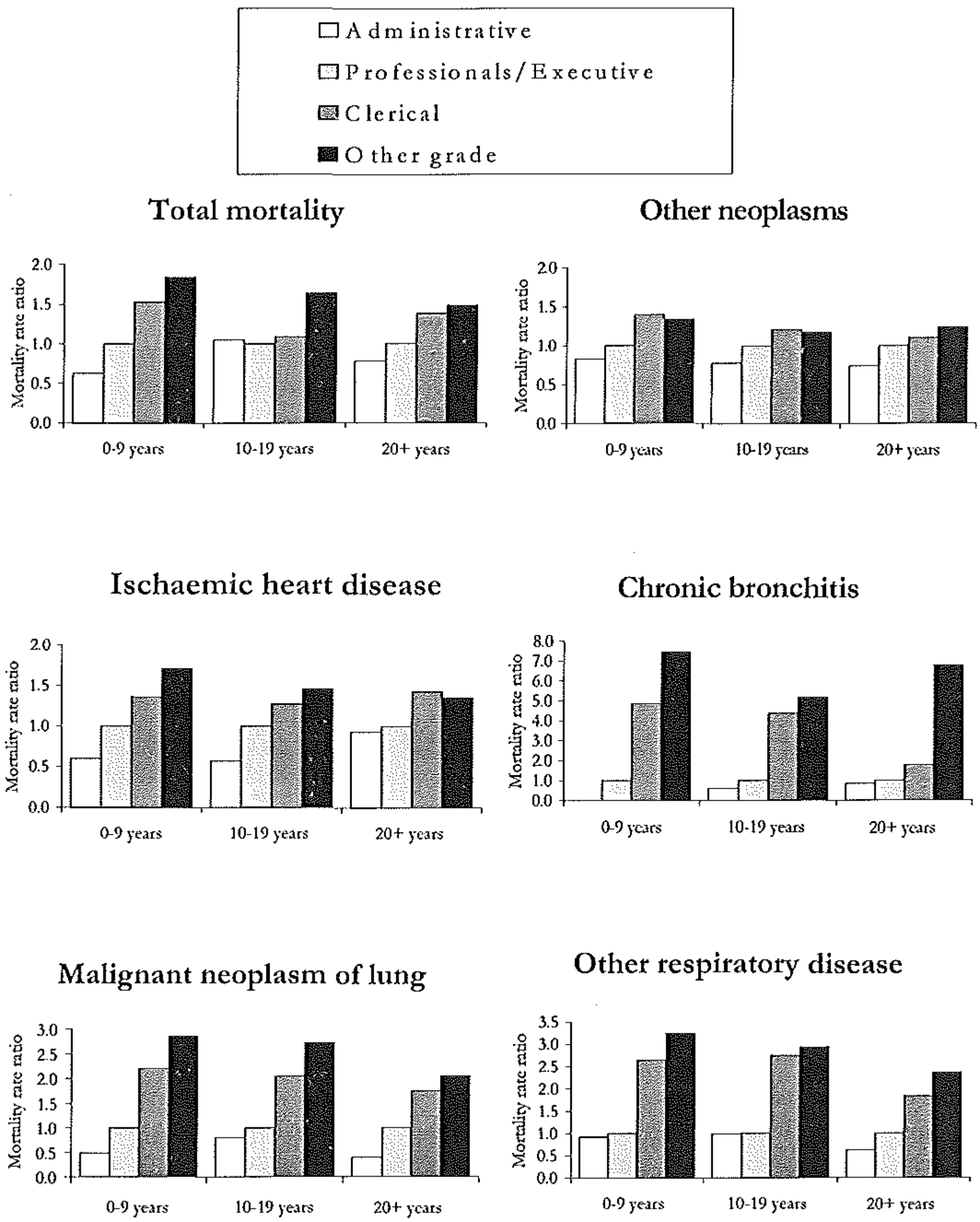


Table 3.2.4 Mortality rate ratios for 'other' grade versus administrative by age at death.

Causes of death (ICD-8)	40-64 years (221,720 person-years)		65-69 years (72,166 person-years)		70 years and older (91,775 person-years)	
	No. of deaths	Mortality rate ratio *(95%-CI)**	No. of deaths	Mortality rate ratio *(95%-CI)**	No. of deaths	Mortality rate ratio *(95%-CI)**
All causes	1,881	2.91 (2.42-3.50)	1,453	2.15 (1.75-2.65)	4,719	1.72 (1.54-1.92)
Malignant neoplasm of lung (162.1)	193	5.35 (3.15-9.11)	147	3.22 (1.75-5.93)	362	3.61 (2.48-5.26)
Other neoplasms (140-239, excl. 162.1)	415	1.76 (1.16-2.67)	332	1.68 (1.07-2.66)	933	1.17 (0.91-1.52)
Ischaemic heart disease (410-414)	779	2.57 (1.93-3.43)	539	1.71 (1.22-2.41)	1,443	1.44 (1.18-1.76)
Cerebrovascular disease (430-438)	80	2.50 (1.02-6.11)	95	1.16 (0.50-2.72)	456	1.17 (0.81-1.67)
Other cardiovascular (390-404,420-429,440-458)	130	2.07 (1.00-4.30)	106	3.04 (1.44-6.42)	436	1.79 (1.26-2.55)
Chronic bronchitis (491-492)	34	29.77 (9.03-98.11)	28	8.80 (2.28-33.98)	83	8.25 (3.81-17.86)
Other respiratory disease (460-490,493-529)	71	4.71 (1.89-11.75)	85	5.21 (2.29-11.82)	548	3.66 (2.71-4.95)
Gastrointestinal disease (520-577)	29	10.30 (2.74-38.78)	31	0.48 (0.09-2.54)	109	2.24 (1.11-4.53)
Genito-urinary disease (580-607)	16	9.44 (1.54-57.82)	12	2.84 (0.33-24.78)	74	2.58 (1.12-5.94)
Accident and violence (800-949,960-978)	38	3.94 (1.07-14.55)	12	11.01 (1.37-88.6)	31	0.73 (0.17-3.11)
Suicide (950-958,980-989)	34	1.61 (0.35-7.32)	14	3.98 (0.55-28.85)	20	0.73 (0.12-4.60)
Other deaths	52	4.09 (1.34-12.42)	49	3.94 (1.23-12.55)	216	0.92 (0.53-1.57)
Causes not related to smoking†						
Neoplasms	252	1.58 (0.92-2.74)	198	1.52 (0.83-2.76)	601	0.92 (0.67-1.28)
Non-neoplasms	450	3.31 (2.27-4.81)	404	2.65 (1.79-3.93)	1,890	1.89 (1.60-2.24)

* Adjusted for age and length of follow-up.

CI Confidence interval.

† All causes less 140-141, 143, 149, 150, 157, 160-163, 188-189, 200, 202, 410-414, 491, 492

for mortality caused by chronic bronchitis, gastrointestinal disease and genito-urinary disease. Most of the decrease in the gradient for these causes was seen between the youngest pre-retirement, age group and the older two age groups.

3.2.5 Discussion

After more than 25 years of follow-up of civil servants, aged 40-69 years at entry to the study, the inverse gradient by employment grade still existed in all cause mortality and for nearly all specific causes of death. The mortality rates were highest in the lower employment grades. Cardiovascular disease and cancers contributed most to the absolute differences in the all cause mortality rates by employment grade although the largest relative differences are found for respiratory diseases (chronic bronchitis, lung cancer). The strength of the associations for the specific cardiovascular causes of death did not vary materially. About one third of the employment grade differences could be explained by the distribution in the major risk factors. Except for lung cancer, differences between employment grades are also found in subjects with a low blood pressure, who are not smoking and have a low plasma cholesterol level. Employment grade differences declined slightly after more years of follow-up, but are still present in the survivors after 20 years of follow-up. The decline in relative differences in mortality with age was the highest for chronic bronchitis, gastrointestinal disease and genito-urinary diseases. However, even in retired subjects, socioeconomic differences were found for almost all causes of death.

Before discussing possible mechanisms behind these differences, some potential artefactual explanations need to be considered. All subjects were, at entry to the study, working in stable, sedentary jobs in one location, so that the civil service employment grade categories produce groups which are more homogeneous, for example, with respect to aspects of material circumstances, than most socioeconomic groups in other similar studies of inequalities. As a consequence, differentials might expected to be larger than equivalent socioeconomic differences in the British population.[15]

In addition, our findings might be affected by misclassification of the causes of death or employment grade. There is evidence that, in the past, working class patients were more likely to be diagnosed as suffering from other myocardial degeneration while middle class patients were more likely to receive a more specific diagnosis of angina pectoris. However, Samphier et al reported a study in which they matched the diagnostic agreement about cause of death between clinicians and pathologists.[16] They concluded that although the diagnostic agreement does indeed vary with social class of the patient, the variation is small and in all the major diagnostic chapters, except respiratory diseases, the effect of correcting such diagnostic biases would either not affect or steepen existing class gradients. Thus, the steep differences for respiratory diseases may partly be a consequence of under diagnosis in the higher employment grades and over diagnosis in the lower employment grades.

Any misclassification of employment grade is not likely to be large. In addition, employment grade as an indicator of socioeconomic status has been shown to be a powerful predictor of mortality and morbidity and generally has shown steeper mortality differentials than national data based on the Registrar General's classification of occupations.

Explanations for the social class inequalities in morbidity and mortality have been sought in health selection or in health related behavioural or material factors which are differently distributed over the employment grades.[17] Unfortunately, we did not measure morbidity or changes in employment grade. However, our differentials found after 20 years of follow-up and results from other studies, suggest that the effect of selective social mobility is limited.[18,19] Similar to the results after 10 years of follow-up,[6] the main risk factors of smoking, blood pressure, cholesterol and glucose, as measured at the initial examination, explain about one third of the socioeconomic differentials in mortality. The contribution of risk factors to the explanation of the inequalities depends upon the fact that the risk factors were measured only once, at baseline, and so provide probably weaker measures of the true risk factors with increasing length of follow-up, since the risk profile may change. However, previous analysis has shown that the predictive value of cholesterol measurements is larger with increasing time gap between measurement and death.[20] The contribution of risk factors to the explanation of the inequalities depends also upon the strength of the association between these factors and socioeconomic status and also on the diversity of risk factors that can cause the disease. It is interesting to contrast the results for lung cancer and respiratory disease in those men at low risk with the results of the total population in this respect. The attributable risk for smoking on lung cancer is quite high and we do not see socioeconomic differentials for lung cancer in the low-risk group. However, the increased employment grade gradient for respiratory disease in the low risk men suggests that, besides smoking, the working and living environment may differ among the employment grades. The underlying risk factors for diseases might also explain the diversity in differentials for cancers compared to the similarity in differentials for cardiovascular disease. In contrast to cancer, ischaemic cardiovascular disease is a so-called 'general disease'. The process of atherosclerosis occurs in the whole arterial system, thus, most cardiovascular diseases have the same risk factors, while the risk factors for cancers are quite different.

Apart from the major risk factors of smoking, blood pressure, glucose and cholesterol, other behavioural or material factors might play a role in inequalities. One of these factors is unfavourable working conditions which may be linked either to external harmful exposures such as chemicals, or dust pollution in industrial settings or to stress, or job control more generally.[21-23] Our study population were office-based civil servants, but despite the relatively homogeneous study population, working circumstances might vary by employment grade. The observed decline in employment grade differences after retirement age for most causes of mortality suggest that working conditions might explain some of these inequalities. For example, it is known that gastrointestinal diseases are associated with occupational stress,[24] and that chronic bronchitis can be induced by working conditions.[25] We do, indeed see large changes in the employment grade gradient for these outcomes after retirement. The effect of some working conditions, which contribute to the differentials in health and mortality, may continue to have influence into the old age. For example, the lag time between some exposures and a disease would pass the retirement age. Similarly, behavioural factors, which may be associated with employment grade, will not change on the day of retirement.

An additional explanation for the socioeconomic differences in mortality has been suggested: employment grade is associated with factors that influence someone's general susceptibility to diseases.[5] Our results support this assertion, as the main risk factors could not fully explain the employment grade differences in all causes of death. Furthermore, among a low risk group with respect to hypertension, cholesterol and smoking, employment grade differences in mortality were still found. In addition, the results suggest that this general susceptibility continuous through into retirement. Despite this, we can conclude that persons with a higher socioeconomic status are consistently better off compared to lower socioeconomic groups. The mechanism behind this needs further research.

The diminishing inequalities with age might be due to the declining influence of work circumstances, but there are other possible explanations. First, the decline could be artefactual. On average, the time interval since the measurement of employment grade would tend to be longer for the oldest age group and this would tend to diminish the effect of grade. However this explanation is not likely to explain all differences since we found inequalities after 20 years of follow-up. Second, the decline could be caused by selective mortality. It is likely that selective removal of sick people results in a relatively healthier population. However, other analyses of this cohort have shown that differential mortality due to hypertension and hypercholesterolaemia is limited, and the effect due to smoking is small.[26] Third, the larger inequalities in the younger age groups relate to the fact that in the United Kingdom, in recent decades, the inequalities are widening[27] and thus this suggests that, in the future, among elderly people the inequalities will also widen.

In conclusion, socioeconomic differentials in mortality still persist at older ages for almost all causes of death. The effect of socioeconomic status thus has a long-term effect. For some specific causes of death the influence of work on inequalities will decline. Further research looking at changes in risk factors may be helpful in elucidating the aetiology of inequalities. For this reason, the surviving men in this cohort are currently being re-contacted to obtain updated risk factor information. We conclude that, together with more general socioeconomic factors, working conditions themselves may affect a broad range of health inequalities among middle-aged men. In addition, social differentials influence most causes of disease and these effects continue through into retirement.

3.2.6 References

1. Valkonen T. *Adult mortality and level of education: a comparison of six countries.* In: Fox J, ed. Health inequalities in European countries. Aldershot: Gower, 1989:142-62.
2. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.
3. Mackenbach JP. Socioeconomic inequalities in health in the Netherlands: impact of a five year research programme. *BMJ* 1994;309:1487-91.
4. Mackenbach JP, Kunst AE, Cavelaars AE, Groenhof F, Geurts JJ. Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet* 1997;349:1655-9.
5. Marmot MG, Rose G, Shipley M, Hamilton PJ. Employment grade and coronary heart disease in British civil servants. *J Epidemiol Community Health* 1978;32:244-9.
6. Marmot MG, Shipley MJ, Rose G. Inequalities in death-specific explanations of a general pattern? *Lancet* 1984;1:1003-6.
7. Guralnik JM, Land KC, Blazer D, Fillenbaum GG, Branch LG. Educational status and active life expectancy among older blacks and whites. *N Engl J Med* 1993;329:110-6.
8. Kaplan GA, Seeman TE, Cohen RD, Knudsen LP, Guralnik J. Mortality among the elderly in the Alameda County Study: behavioral and demographic risk factors. *Am J Public Health* 1987;77:307-12.
9. Martelin T. Mortality by indicators of socioeconomic status among the Finnish elderly. *Soc Sci Med* 1994;38:1257-78.
10. Jefferys M. Social inequalities in health-do they diminish with age? *Am J Public Health* 1996;86:474-5.
11. Marmot MG, Shipley MJ. Do socioeconomic differences in mortality persist after retirement? 25 year follow up of civil servants from the first Whitehall study. *BMJ* 1996;313:1177-80.
12. Reid DD, Brett GZ, Hamilton PJ, Jarrett RJ, Keen H, Rose G. Cardiorespiratory disease and diabetes among middle-aged male Civil Servants. A study of screening and intervention. *Lancet* 1974;1:469-73.
13. Davey Smith G, Shipley MJ, Rose G. Magnitude and causes of socioeconomic differentials in mortality: further evidence from the Whitehall Study. *J Epidemiol Community Health* 1990;44:265-70.
14. SAS-Institute. *SAS user's guide.* Carry NC: SAS Institute Inc, 1985.

15. Davey Smith G, Leon D, Shipley MJ, Rose G. Socioeconomic differentials in cancer among men. *Int J Epidemiol* 1991;20:339-45.

16. Samphier ML, Robertson C, Bloor MJ. A possible artefactual component in specific cause mortality gradients. Social class variations in the clinical accuracy of death certificates. *J Epidemiol Community Health* 1988;42:138-43.

17. Blane D. An assessment of the Black report's explanations of health inequalities. *Sociology Health Illness* 1985;7:423-45.

18. Goldblatt P. Mortality by social class, 1971-85. *Population Trends* 1989;56:6-15.

19. Goldblatt P. Changes in social class between 1971 and 1981: could these affect mortality differential among men of working age? *Population Trends* 1988;51:9-17.

20. Shipley MJ, Pocock SJ, Marmot MG. Does plasma cholesterol concentration predict mortality from coronary heart disease in elderly people? 18 year follow up in Whitehall study. *BMJ* 1991;303:89-92.

21. Marmot M, Theorell T. Social class and cardiovascular disease: the contribution of work. *Int J Health Serv* 1988;18:659-74.

22. Bosma H, Marmot MG, Hemingway H, Nicholson AC, Brunner E, Stansfeld SA. Low job control and risk of coronary heart disease in Whitehall II (prospective cohort) study. *BMJ* 1997;314:558-65.

23. Marmot MG, Bosma H, Hemingway H, Brunner E, Stansfeld S. Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet* 1997;350:235-9.

24. Hill P. It is not what you eat, but how you eat it digestion, life-style, nutrition. *Nutrition* 1991;7:385-95.

25. House JS, Strecher V, Metzner HL, Robbins CA. Occupational stress and health among men and women in the Tecumseh Community Health Study. *J Health Soc Behav* 1986;27:62-77.

26. van de Mheen PJ. *Facts and artefacts. Variation in risk factor and the impact on estimated potential health benefits* [Dissertation]. Amsterdam: University of Amsterdam, 1997.

27. Marmot MG, McDowall ME. Mortality decline and widening social inequalities. *Lancet* 1986;2:274-6.

3.3 Seasonal variation in cause specific mortality; Are there high-risk groups? The first Whitehall Study

3.3.1 Abstract

Objectives. To determine the effect of season on all cause and cause specific mortality and to identify high-risk groups.

Design. 25-year follow-up study.

Setting. The first Whitehall Study.

Subjects. 19,019 male civil servants aged 40-69 years who attended the screening examination between 1967 and 1970.

Main outcome measure. Ratio of highest mortality rate during winter versus lowest mortality rate during summer.

Results. There were seasonal effects for mortality due to all causes (winter versus summer rate ratio 1.22 95%-CI 1.1-1.3), respiratory disease (1.98 95%-CI 1.6-2.4) and ischaemic heart disease (1.27 95%-CI 1.1-1.7). Ischaemic heart disease, the commonest cause of death, contributed the largest part of the absolute difference in all cause winter excess mortality. The excess of death in winter was greater among older people, because they were dying (also in summer) more of seasonal sensitive diseases. Low civil service employment grade was not associated with higher seasonality in mortality than high employment grade. Participants with cardiovascular disease showed greater seasonality from all cause mortality and from the seasonal sensitive diseases. Participants identified as high risk for mortality due to cardiovascular diseases based on the Framingham risk equation had greater seasonality in stroke mortality than those at low risk, although there was no effect of risk group on all cause or ischaemic heart disease mortality.

Conclusions. In terms of absolute risk, the winter excesses in ischaemic heart disease and respiratory disease together explain more than three quarters of the winter excess in all cause mortality. There is not much evidence that high-risk groups are subject to greater seasonal variations in mortality. However, those who are already diseased are more prone to the affects of season. Further research is necessary to investigate the possibilities of focussing the interventions on the whole population and those already diseased in order to prevent these seasonal deaths.

3.3.2 Introduction

Mortality rates show strong seasonal effects in high latitude countries, with all cause mortality rates highest in the winter.[1-5] Over half of the excess is due to cardiovascular disease with much of the remainder due to respiratory diseases.[1,2,4] The mechanisms underlying seasonal variation in mortality are not clear, but may include environmental temperature, air pollution, sunlight exposure, activity pattern, influenza incidence, psychological condition and/or food intake, and their effects on physiological mechanisms related to disease.

Identification of groups who are at high risk for a seasonal death offers the opportunity to both elucidate potential mechanisms and to target preventive interventions. Previous studies have suggested that the winter excess may be greater amongst people of lower social class[6] (who may for example be less able to afford adequate housing insulation or central heating), older people and those with pre-existing health problems;[7] the seasonal variation in blood pressure may be greater among smokers compared to non-smokers.[8]

However, these studies have been limited by a narrow range of factors with which to characterise individual risk, and insufficient events for cause specific analyses of adequate power. We sought therefore in the Whitehall Study of British male civil servants to determine the effect of season on all cause and cause specific mortality and to determine whether high-risk groups could be identified on the basis of age, employment grade, or those who are already diseased.

3.3.3 Subjects and methods

A total of 19,019 male civil servants aged 40-69 years attended the screening examination of the Whitehall Study between September 1967 and January 1970. In short, each participant filled in a standard questionnaire that included age, self-reported smoking, civil servants' employment grade, and cardiovascular symptoms. Employment grade, a measure of socioeconomic status, was categorised as high grades (administrative, professional and executive) and low grades (clerical and other grades, e.g. messengers and other unskilled manual workers). For the analyses using employment grade, 886 men from the Diplomatic Service and the British Council were excluded, as their employment status was not comparable with the employment grades above. Smoking habits were classified into never/ex-smokers and current smokers. At the screening examination a single blood pressure reading was obtained with the participant seated and blood drawn for plasma cholesterol estimation. More details regarding design and methods are described elsewhere.[9]

Subjects were classified into groups with differing degrees of risk on the basis of the updated Framingham coronary risk score.[10] This score used information on age, smoking status, blood pressure, cholesterol, diabetes and presence of a tall left ventricular R-wave from the ECG. A fixed value of 1.2 mmol/L was used for HDL cholesterol for all subjects since this was not measured at screening. Subjects were ranked according to their Framingham score and classified as either low risk (<60th percentile), medium risk (60th-80th percentile) or high risk (>80th percentile). In addition, subjects were classified according to the presence or absence of cardiovascular disease. These were defined as presence of reported angina, prolonged chest pain ('pain of possible myocardial infarction), previous admission to hospital for coronary heart disease or positive for ischaemia from the ECG (any of Minnesota codes 1.1-3, 4.1-4, 5.1-3 or 7.1).

Records from 99.3% men were flagged at the National Health Service Central Registry, which notified us of all deaths up to the end of January 1995. Causes were classified according to the International Classification of Disease, eighth revision (ICD-8). The following codes were analysed: ischaemic heart disease (410-414), cerebrovascular disease (430-438), other cardiovascular diseases (390-404,420-429, 440-48), malignancy (140-239) and respiratory disease (460-519). For 28 persons, cause of death was missing and these persons were excluded from all analyses. In total 18,841 men were followed up for at least 25 years with 8,347 having a known cause of death.

Data analysis

We created an expanded data set for these analyses in which for each subject and each individual month of follow-up a new record was created giving the total days of follow-up during that month. Deaths were allocated to the appropriate month, current age group, calendar year and high-risk groups. This analysis allows for the fact that recruitment into the study took just over two years and also for the differing lengths of the months. This expanded data set was then summarised by computing the total number of deaths from each specific cause and the total person time at risk in these separate categories. Creation of the summary data set was done using the statistical package SAS.

Seasonal variation in mortality was modelled assuming that the outcome of interest followed a sinusoidal curve with a period of one year. This curve can be described mathematically using just two parameters: a sine and cosine term. The test of seasonality was computed using a likelihood ratio test with two degrees of freedom by comparing two models, with and without the seasonality terms. The models with the seasonal components were also compared with models showing overall heterogeneity between the twelve months to assess whether the seasonal model described the month to month variation adequately. The sinusoidal variations in mortality rates can be summarised using

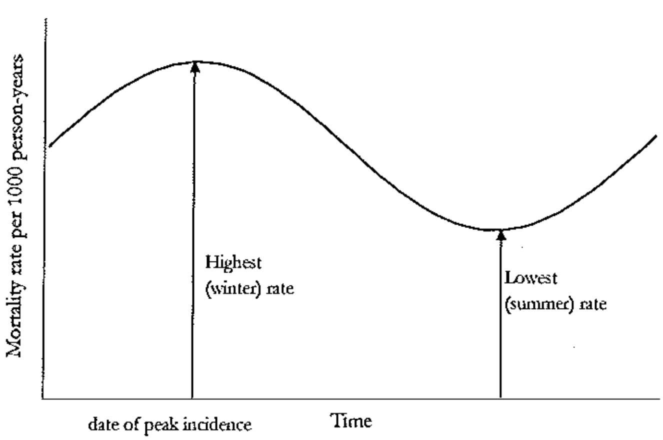


Figure 3.3.1
Model of seasonal variation in mortality.

two useful terms; one showing the month of peak incidence and the other showing the estimated ratio of the highest (winter) to lowest (summer) incidence rates (see Figure 3.3.1). Both these terms can be derived using the coefficients of the sine and cosine parameters and have been used to describe the seasonal effects.

For the analyses of the seasonal effect by age, by employment grade, by the Framingham risk groups and by cardiovascular disease, the highest (winter) to lowest (summer) mortality rate ratios were assessed for all calendar years combined. Tests for differences in the magnitude of the seasonality effect between risk groups were computed using the more conservative test of heterogeneity, rather than test of trend. In cases where the seasonality effect actually changes monotonically across risk groups, a test for trend would have given a more extreme *P*-value.

All models for mortality were fitted using Poisson regression with the statistical package GLIM, which was also used to compute the mortality rate ratios and 95%-confidence intervals.

3.3.4 Results

Figures 3.3.2 and 3.3.3 show the seasonal variation in all cause and cause specific mortality rates respectively. The number of deaths, test of seasonality, estimated month of the peak incidence and the highest : lowest ratio by cause of death are shown in Table 3.3.1. A strong seasonal variation was seen for all cause mortality. These differences were mainly due to seasonal variation in ischaemic heart diseases, cerebrovascular diseases and respiratory diseases with a slight effect due to 'other cardiovascular diseases'. No seasonal fluctuation was seen for neoplasm and 'other' deaths. All models containing seasonality terms showed adequate fits to the observed month by month mortality rates. For most causes of death showing seasonal effects, the winter peak was in January. The largest relative fluctuation of the mortality rates with season was seen for respiratory diseases. During the winter peak the respiratory disease mortality rate was nearly twice that of the lowest rate (1.98 95%-CI 1.6-2.4). However, ischaemic heart disease, the commonest

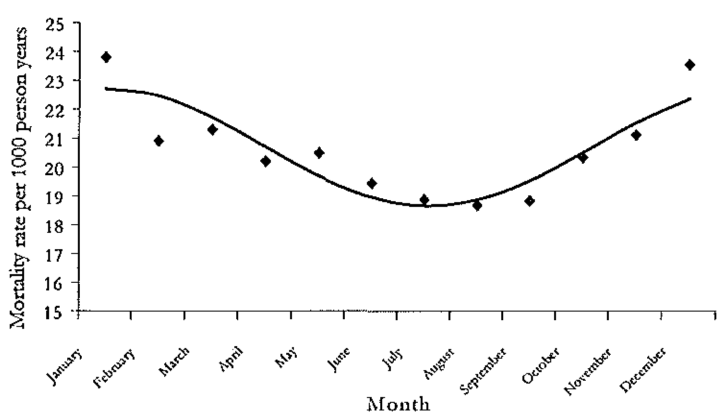
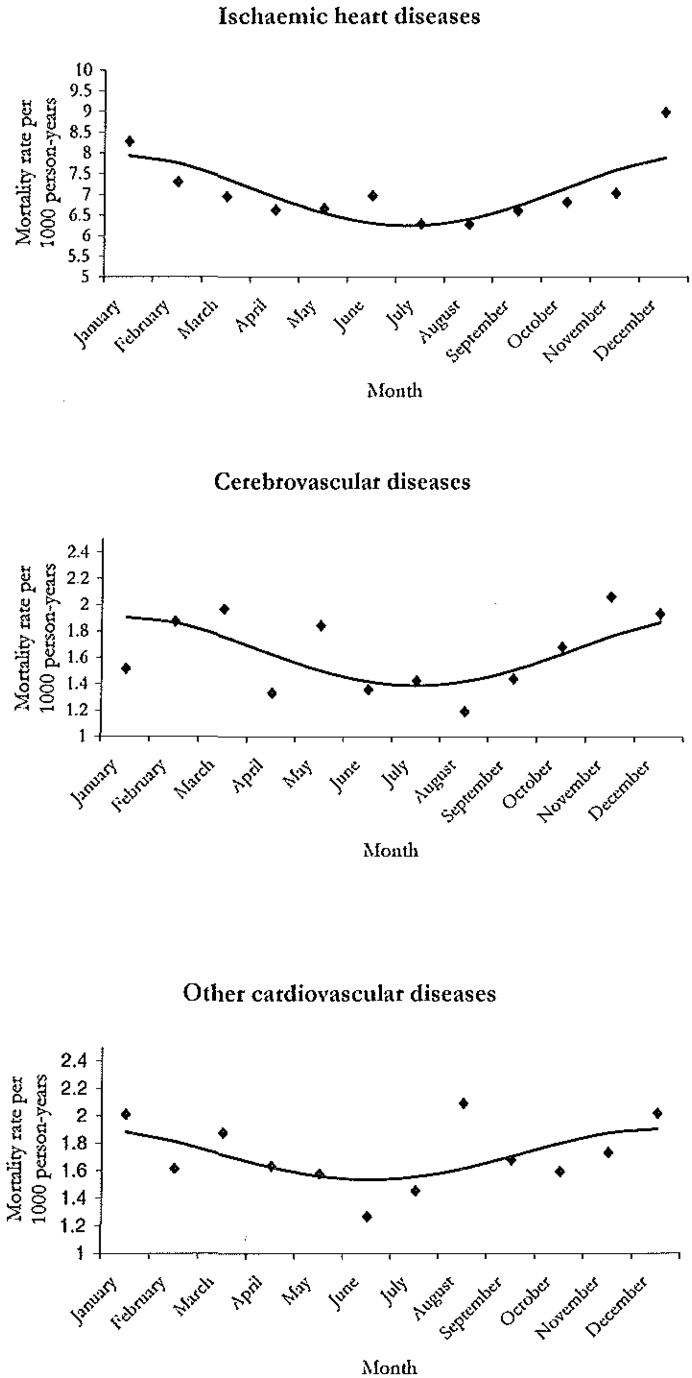
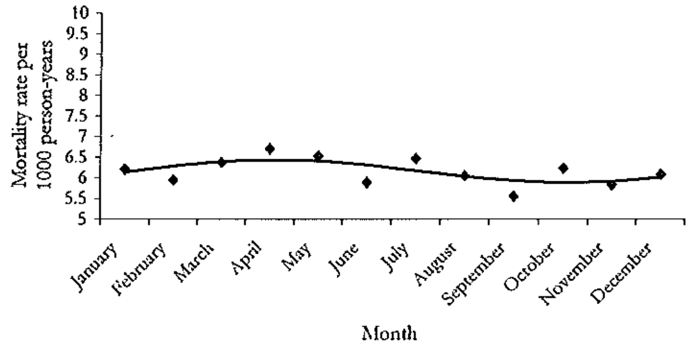


Figure 3.3.2 Seasonality in mortality rates.

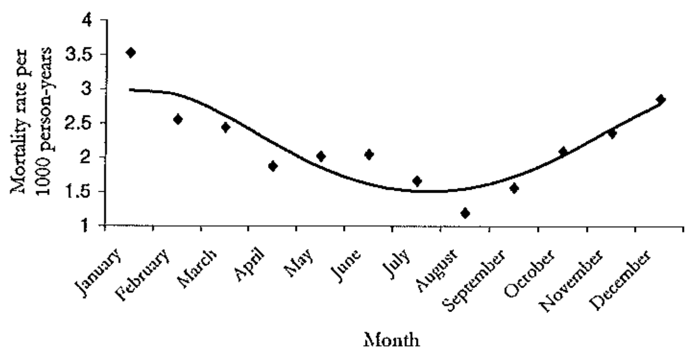
Figure 3.3.3 Seasonality in mortality rates by cause of death.



Neoplasms



Respiratory diseases



Other Causes

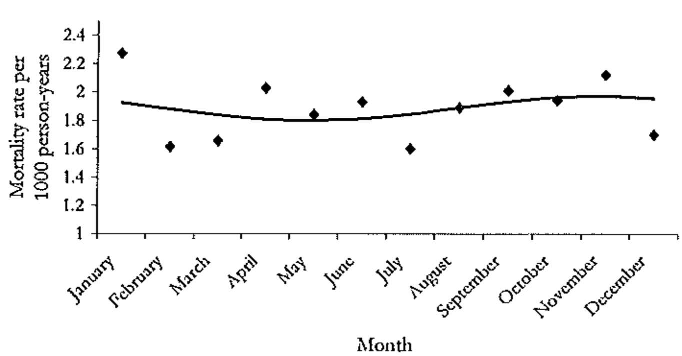


Table 3.3.1 Number of deaths, heterogeneity of rates, test of seasonality, estimated date of the highest peak and rate ratio of the highest : lowest mortality rates by cause of death.

Cause of death (ICD-8)	No. of deaths	Overall heterogeneity of rates with 11 df	Test of seasonality with 2 df	Month of highest mortality rate	Rate ratio of highest:lowest† (95%-CI)
All causes	8,347	50.38***	39.61***	January	1.22 (1.14-1.29)
Ischaemic heart diseases (410-414)	2,858	32.52***	20.45***	January	1.27 (1.14-1.41)
Cerebrovascular diseases (430-438)	661	19.55	8.17*	January	1.37 (1.10-1.70)
Other cardiovascular disease (390-404, 420- 429,440-458)	694	13.31	4.04	December	1.24 (1.01-1.53)
Neoplasms (140-239)	2,489	6.44	2.43	April	1.09 (0.98-1.22)
Respiratory diseases (460-519)	882	65.74***	50.64***	January	1.98 (1.64-2.40)
Other deaths	763	8.55	0.78	November	1.09 (0.90-1.34)

† Ratio of highest mortality rate in 'winter': lowest mortality rate in 'summer', adjusted for age.
df Degrees of freedom.
CI Confidence interval.
*** P <0.001; ** P <0.01; * P <0.05.

cause of death, contributed the greatest part to the absolute difference between the lowest (summer) and the highest (winter) rates in all cause mortality and, together with respiratory disease accounted for over three quarters of this difference.

In Table 3.3.2 the amplitudes of the seasonal fluctuation are given for three different groups of age at death. The seasonal fluctuation in all cause mortality rates tended to increase with age (P-value for heterogeneity = 0.06). However, this increase in seasonal fluctuation with age was not so marked for the specific causes which show a seasonal pattern (Test of heterogeneity: P = 0.27 for ischaemic heart diseases and P > 0.50 for cerebrovascular diseases and respiratory diseases). The difference between the seasonal variation in all cause mortality between the younger and older age groups was due to the different pattern of causes of death in these age groups. The proportion of deaths due to respiratory disease, which showed the largest seasonal variation, increased from 6% at ages 40-64 up to 16% at ages 75 or more.

There is some indication that the amplitude of seasonal fluctuation in mortality is decreasing compared over recent decades.[6,11,12] To test whether this trend continues in

Table 3.3.2 *Ratio of highest : lowest mortality rates by cause of death and age at death.*

Causes of death (ICD-8)	Age at death: 40-64 years: No. of deaths	40-64 years: Rate ratio of highest: lowest* (95%-CI)	65-74 years: No. of deaths	65-74 years: Rate ratio of highest : lowest* (95%-CI)	75 years and above: No. of deaths	75 years and above: Rate ratio of highest: lowest* (95%-CI)	*P*-value
All causes	1,908	1.08 (1.0-1.2)	3,422	1.23 (1.1-1.4)	3,017	1.32 (1.2-1.5)	0.06
Ischaemic heart diseases (410-414)	794	1.11 (0.9-1.4)	1,198	1.33 (1.1-1.6)	866	1.35 (1.1-1.6)	0.27
Cerebrovascular diseases (430-438)	85	1.78 (1.0-3.3)	261	1.68 (1.2-2.4)	315	1.37 (1.0-1.9)	>0.5
Respiratory diseases (460-519)	106	1.76 (1.0-3.0)	307	2.27 (1.6-3.2)	469	1.98 (1.5-2.6)	>0.5

* Ratio of highest mortality rate in 'winter': lowest mortality rate in 'summer', adjusted for age

CI Confidence interval

Table 3.3.5 *Ratio of highest : lowest mortality rates* by causes of death by Framingham risk groups.*

Causes of death (ICD-8)	Framingham risk group: Lowest risk group (< 60th percentile) *(n=10,837)*: No. of deaths	Lowest risk group: Rate ratio of highest: lowest† (95%-CI)	Middle risk group (60th – 80th percentile) *(n=3,609)*: No. of deaths	Middle risk group: Rate ratio of highest: lowest† (95%-CI)	High risk group (> 80th percentile) *(n=3,605)*: No. of deaths	High risk group: Rate ratio of highest: lowest† (95%-CI)	*P*-value
All causes	3,273	1.20 (1.1-1.3)	2,082	1.25 (1.1-1.4)	2,642	1.23 (1.1-1.4)	0.22
Ischaemic heart diseases (410-414)	1,006	1.36 (1.1-1.6)	738	1.30 (1.1-1.6)	1,003	1.19 (1.0-1.4)	>0.5
Cerebrovascular diseases (430-438)	234	1.11 (0.8-1.6)	156	1.64 (1.0-2.6)	243	2.08 (1.4-3.0)	0.05
Respiratory diseases (460-519)	308	1.74 (1.3-2.4)	231	1.98 (1.4-2.9)	296	2.38 (1.7-3.3)	0.42

† Ratio of highest mortality rate in 'winter': lowest mortality rate in 'summer', adjusted for age.

CI Confidence interval

Table 3.3.3 Ratio of highest : lowest mortality rates for cardiovascular and respiratory diseases by age at death and calendar period.

Age at death	Calendar period														
	1967-1974			1975-1979			1980-1984			1985-1989			1990-1995		
	n	%	RR* (95%-CI)	n	%	RR* (95%-CI)	n	%	RR* (95%-CI)	n	%	RR* (95%-CI)	n	%	RR* (95%-CI)
40-54 years	105	53	1.48 (0.9-2.6)	51	59	†	15	68	†	‡			‡		
55-59 years	141	61	1.75 (1.1-2.8)	114	64	0.79 (0.5-1.3)	62	57	†	13	52	†	‡		
60-64 years	168	58	1.57 (1.0-2.4)	178	61	0.77 (0.5-1.2)	161	61	1.41 (0.9-2.2)	88	51	†	20	51	†
65-69 years	124	59	1.24 (0.8-2.0)	203	63	2.03 (1.4-3.0)	219	59	1.60 (1.1-2.3)	218	59	1.47 (0.5-1.2)	126	50	1.74 (1.1-2.9)
70-74 years	36	64	†	186	63	1.50 (1.0-2.3)	306	62	1.42 (1.0-2.0)	316	61	1.41 (1.0-2.1)	303	56	1.53 (1.1-2.1)
75-79 years	0		†	45	71	†	200	66	1.29 (0.9-1.9)	356	63	1.44 (1.0-1.9)	431	63	1.34 (1.0-1.8)
80-84 years	‡			0		†	52	70	†	202	65	1.38 (1.1-1.9)	402	64	1.90 (1.4-2.5)
≥ 85 years	‡			‡			1	100	†	55	81	†	198	63	1.6 (1.1-2.4)

* Ratio of highest mortality rate in 'winter': lowest mortality rate in 'summer.

n No. of deaths due to cardiovascular and respiratory diseases (ICD-8: 410-414, 430-438, 390-404, 420-429, 440-458, 460-519).

% Proportion of cardiovascular and respiratory death of all causes of death.

CI Confidence interval.

† Rate ratio for highest: lowest was only computed when number of deaths > 100.

‡ No deaths since cell has no person-years of follow-up.

the last two decades we calculated the amplitudes stratified both by age group and calendar period. No clear decreasing effect of seasonal variation in all cause mortality was observed (results not shown). However, this variation in all cause mortality could be biased by the pattern of causes of death. For that reason, we assessed the amplitude of the seasonal fluctuation in those causes of death that showed a seasonal pattern, i.e. cardiovascular diseases and respiratory diseases. Table 3.3.3 shows that, after stratifying and controlling for age at death, in the last three decades no clear decreasing effect of season on causes with a seasonal pattern exists. However, the proportion of deaths due to seasonally related causes decreased slightly.

Table 3.3.4 shows the ratios of the highest rate in winter versus the lowest rate in summer for the higher employment grade and the lower employment grade. In relative terms, the lower grade had higher rates for mortality from most causes of death, but no significant differences were seen in the seasonal fluctuations between the two employment grades ($P > 0.50$ for all comparisons).

Table 3.3.4 Ratio of highest : lowest mortality rates by cause of death and employment grade.

	Employment grade			
	High grades *(n=13,231)*		Low grades *(n=4,770)*	
Causes of death (ICD-8)	No. of deaths	Rate ratio of highest:lowest* (95%-CI)	No. of deaths	Rate ratio of highest:lowest* (95%-CI)
All causes	5,013	1.23 (1.1-1.3)	3,019	1.22 (1.1-1.4)
Ischaemic heart diseases (410-414)	1,784	1.34 (1.2-1.5)	977	1.22 (1.0-1.5)
Cerebrovascular diseases (430-438)	406	1.28 (1.0-1.7)	225	1.59 (1.1-2.3)
Respiratory diseases (460-519)	403	2.07 (1.6-2.8)	446	2.00 (1.5-2.6)

* Ratio of highest mortality rate in 'winter': lowest mortality rate in 'summer', adjusted for age.

CI Confidence interval.

Table 3.3.5 (on page 70) shows the amplitudes of the seasonal effect by Framingham risk groups. For all cause mortality, the seasonality effect does not differ by risk group. However, for stroke mortality the rate ratio is highest in the high-risk group 2.08 (95%-CI 1.4-3.0) and lowest in the low-risk group 1.11 (95%-CI 0.8-1.6).

Table 3.3.6 shows the amplitudes of the seasonal effect by cardiovascular disease. Men with cardiovascular disease show seasonal variation in all cause mortality (P-value for heterogeneity = 0.03) and non-significant for the seasonally related causes of death.

Table 3.3.6 Ratio of highest : lowest mortality rates by cause of death and cardiovascular disease.

Causes of death (ICD-8)	Cardiovascular disease			
	No *(n= 15,554)*		Yes *(n= 3,284)*	
	No. of deaths	Rate ratio of highest:lowest† (95%-CI)	No. of deaths	Rate ratio of highest:lowest† (95%-CI)
All causes	6,389	1.18 (1.1-1.3)	1,972	1.38 (1.2-1.6)
Ischaemic heart diseases (410-414)	2,006	1.26 (1.1-1.4)	847	1.31 (1.1-1.6)
Cerebrovascular diseases (430-438)	510	1.35 (1.1-1.7)	150	1.48 (0.9-2.3)
Respiratory diseases (460-519)	670	1.91 (1.5-2.4)	211	2.33 (1.6-3.5)

† Ratio of highest mortality rate in 'winter': lowest mortality rate in 'summer', adjusted for age.

CI Confidence interval

3.3.5 Discussion

In terms of absolute risk, the winter excess in ischaemic heart disease contributes the largest part to the winter excess in all cause mortality. The excess of death in winter was greater among elderly people, since a greater proportion of deaths in elderly people are from seasonally sensitive causes. The winter versus summer mortality rate ratios for these seasonally sensitive causes, however, do not change with age. Furthermore, during the last decades there was a slight decrease in the proportion of people dying of seasonally sensitive diseases, but, the winter versus summer mortality rate ratios did not change significantly from 1967 to 1995. Men with cardiovascular disease showed significantly greater seasonality for all cause mortality and non-significant increases for seasonally affected causes of death. For stroke mortality, but not all cause mortality, groups at high risk of subsequent cardiovascular event based on the Framingham equation, were associated with greater seasonality in mortality than lower risk groups.

To appreciate the findings, certain aspects of the study must be considered. In several studies the winter excess in mortality is examined in hospital based studies.[13-15] Rothwell reported that the widely varying winter excess in mortality in hospital based studies might be an artifact of a variation in the likelihood of hospital admissions.[16] Our study is free from this possible bias since we studied seasonal variation in a work-based study. The study population consisted only of male civil servants in London and the use of these quite homogenous groups removes the effect of some possible confounding factors. This study population has proved to comprise sufficient variation in socioeconomic status to show large mortality differences.

Our method to assess the amplitude of the seasonal variation (rate ratio of the highest versus the lowest) provides a simple, although statistically powerful, model for the true variation in mortality rate during the season. There was no evidence, in our data, for any departure from this model. However, it has been found that besides a winter excess, there may also be a heat-related excess in deaths during summer.[7] Our data would need to be augmented with further climate data for the whole of the follow-up period and require more deaths to be able to investigate this hypothesis.

A winter excess in mortality due to respiratory diseases, cardiovascular disease and stroke is reported in several other studies.[1,16-24] Possible mechanisms to explain the seasonal variation in mortality are either direct or indirect. First, the environmental temperature itself could give an excess of death. For example, outdoor or indoor air temperature can have a direct biological effect on haemostatis, blood viscosity, lipids, the sympatic nervous system and vasoconstriction.[13,25,26] Secondly, season can be a marker for other variables that show a seasonal variation, such as air pollution, wind speed, an increased incidence of influenza, but also food habits, activity patterns, smoking habits (more smoking indoors during winter) stress factors such as loneliness. Several psychosocial stressors seem to shown a larger effect on blood pressure levels during winter.[14] Mundal et al showed that the seasonal fluctuation in physical fitness may provide an explanation for the seasonal variation in blood pressure.[27]

The rise in respiratory diseases during winter might be explained by the rise in influenza epidemics during winter.[12,28] Kunst et al have reported that influenza may explain 34% of the cold related mortality in The Netherlands.[29] The rise in influenza might also cause a rise in cardiovascular disease during winter.[30] Several other cardiovascular risk factors have been shown to exhibit seasonal variation; e.g. in cholesterol,[26,31,32] in haemostatic factors, fibrinogen,[26,30,33-36] and in blood pressure.[8,13,37]

It has been hypothesised that elderly people are more sensitive to seasonal effects, as it is likely that among elderly people influenza epidemics are more frequent or that their body response to the outside temperature is less adequate. Furthermore, it has been found that, blood pressure varies more among elderly people between winter and summer.[25,38] Our finding that the excess of deaths in winter is larger among elderly people is consistent with this hypothesis. However, in contrast to other studies which also reported age-gradients for specific causes of death,[2,4,6,19,28] the ratio of the mortality rate for specific causes of death during winter and during summer in our study remains the same with increasing age. Thus elderly people appear not more sensitive to seasonal effects, but they are more likely to die from causes with a seasonal pattern. This is similar to results of a study in nursing home residents which suggested that the presence of health problems, and not age as such, determined the seasonal fluctuation in mortality.[7]

We expected that the seasonal variation in mortality might be larger among the high-risk groups similar to the finding of Curwen that the mortality during winter is higher among the lower socioeconomic groups compared to the higher socioeconomic groups.[4,6]

For example, during winter the blood pressure distribution shifts in total to a higher level and we would expect that this would cause a relatively larger problem for men in the lower grade: since they may have, on average, poorer housing insulation and less central heating. This does not mean that the high-risk groups have the same risk of death during winter compared to low risk groups, the absolute mortality rate would be still higher. This suggests that other factors, such as direct biological factors which are not unequally distributed over the high and low-risk groups may be responsible for the seasonal variation in mortality rates.

An interesting finding of this study is that, in general, there were sub-groups that are more sensitive for seasonal variation, although these differences were small. The size of the differences might be due to our study population and study design. At the time of assessment the high-risk groups (at baseline), the study population was still working and relatively healthy. We expect the seasonal variation to be larger in a more heterogeneous study population comprising a wide variation of healthy and unhealthy subjects.

Curwen et al and McDowall et al reported a decline in the seasonal variation by calendar period.[6,12] McDowall et al suggested that the decline in the seasonal variation from the sixties to the eighties was due to increased use of a central heating system and an enormous fall in air pollution.[6] It is likely, indeed, that most of the environmental factors accounting for the seasonal variation have been removed. Our findings do, however, not support the hypothesis that the seasonal variation has more declined sharply during the last decades. Still in absolute terms, the number of people dying from seasonally sensitive diseases is decreasing.

In conclusion, as there is no evidence that high-risk groups are subject to greater seasonal variations in mortality. However, those who are already diseased are more prone to the affects of season. Further research is necessary to investigate the possibilities of focussing the interventions on the whole population and those already diseased in order to prevent these seasonal deaths.

3.3.6. References

1. Mackenbach JP, Kunst AE, Looman CW. Seasonal variation in mortality in The Netherlands. *J Epidemiol Community Health* 1992;46:261-5.

2. Crombie DL, Fleming DM, Cross KW, Lancashire RJ. Concurrence of monthly variations of mortality related to underlying cause in Europe. *J Epidemiol Community Health* 1995;49:373-8.

3. Sakamoto-Momiyama M. Changes in the seasonality of human mortality: a medico-geographical study. *Soc Sci Med* 1978;12:29-42.

4. Curwen M. Excess winter mortality: a British phenomenon. *Health Trends* 1990/91;4:169-75.

5. McKee CM. Deaths in winter: can Britain learn from Europe? *Eur J Epidemiol* 1989;5:178-82.

6. McDowall M. Long term trends in seasonal mortality. *Population Trends* 1981;26:16-9.

7. Mackenbach JP, Borst V, Schols JMGA. Heat-related mortality among nursing-home patients. *Lancet* 1997;349:1297-8.

8. Kristal-Boneh E, Harari G, Green MS. Seasonal change in 24-hour blood pressure and heart rate is greater among smokers than nonsmokers. *Hypertension* 1997;30:436-41.

9. Reid DD, Brett GZ, Hamilton PJ, Jarrett RJ, Keen H, Rose G. Cardiorespiratory disease and diabetes among middle-aged male Civil Servants. A study of screening and intervention. *Lancet* 1974;1:469-73.

10. Castelli WP, Wilson PW, Levy D, Anderson K. Cardiovascular risk factors in the elderly. *Am J Cardiol* 1989;63:12H-19H.

11. Kunst AE, Looman CW, Mackenbach JP. The decline in winter excess mortality in The Netherlands. *Int J Epidemiol* 1991;20:971-7.

12. Curwen M, Devis T. Winter mortality, temperature and influenza: has the relationship changed in recent years? *Population Trends* 1988;53:17-20.

13. Kunes J, Tremblay J, Bellavance F, Hamet P. Influence of environmental temperature on the blood pressure of hypertensive patients in Montreal. *Am J Hypertens* 1991;4:422-6.

14. James GD, Yee LS, Pickering TG. Winter-summer differences in the effects of emotion, posture and place of measurement on blood pressure. *Soc Sci Med* 1990;31:1213-7.

15. Douglas AS, Dunnigan MG, Allan TM, Rawles JM. Seasonal variation in coronary heart disease in Scotland. *J Epidemiol Community Health* 1995;49:575-82.

16. Rothwell PM, Wroe SJ, Slattery J, Warlow CP. Is stroke incidence related to season or temperature? The Oxfordshire Community Stroke Project. *Lancet* 1996;347:934-6.

17. Ballaro A, Cortina-Borja M, Collin J. A seasonal variation in the incidence of ruptured abdominal aortic aneurysms. *Eur J Vasc Endovasc Surg* 1998;15:429-31.

18. Anonymous. Cold at heart. *Lancet* 1989;2:254.

19. Bainton D, Moore F, Sweetnam P. Temperature and deaths from ischaemic heart disease. *Br J Prev Soc Med* 1977;31:49-53.

20. Anderson TW, Le Riche WH. Cold weather and myocardial infarction. *Lancet* 1970;1:291-6.

21. McDowall M. The mortality of agricultural workers: using the thirteenth decennial occupational mortality. *Population Trends* 1986;45:14-17.

22. Rose G. Cold weather and ischaemic heart disease. *Br J Prev Soc Med* 1966;20:97-100.

23. West R. Seasonal variation in CHD mortality. *Int J Epidemiol* 1989;18:463-5.

24. Rogot E, Padgett SJ. Associations of coronary and stroke mortality with temperature and snowfall in selected areas of the United States, 1962-1966. *Am J Epidemiol* 1976;103:565-75.

25. Ballester F, Corella D, Perez-Hoyos S, Saez M, Hervas A. Mortality as a function of temperature. A study in Valencia, Spain, 1991-1993. *Int J Epidemiol* 1997;26:551-61.

26. Stout RW, Crawford V. Seasonal variations in fibrinogen concentrations among elderly people. *Lancet* 1991;338:9-13.

27. Mundal R, Kjeldsen SE, Sandvik L, Erikssen G, Thaulow E, Erikssen J. Seasonal covariation in physical fitness and blood pressure at rest and during exercise in healthy middle-aged men. *Blood Press* 1997;6:269-73.

28. Marshall RJ, Scragg R, Bourke P. An analysis of the seasonal variation of coronary heart disease and respiratory disease mortality in New Zealand. *Int J Epidemiol* 1988;17:325-31.

29. Kunst AE, Looman CW, Mackenbach JP. Outdoor air temperature and mortality in The Netherlands: a time-series analysis. *Am J Epidemiol* 1993;137:331-41.

30. Woodhouse PR, Khaw KT, Plummer M, Foley A, Meade TW. Seasonal variations of plasma fibrinogen and factor VII activity in the elderly: winter infections and death from cardiovascular disease. *Lancet* 1994;343:435-9.

31. Woodhouse PR, Khaw KT, Plummer M. Seasonal variation of serum lipids in an elderly population. *Age Ageing* 1993;22:273-8.

32. Gordon DJ, Hyde J, Trost DC, Whaley FS, Hannan PJ, Jacobs DR, Ekelund LG. Cyclic seasonal variation in plasma lipid and lipoprotein levels: the Lipid Research Clinics Coronary Primary Prevention Trial Placebo Group. *J Clin Epidemiol* 1988;41:679-89.

33. Keatinge WR, Coleshaw SR, Cotter F, Mattock M, Murphy M, Chelliah R. Increases in platelet and red cell counts, blood viscosity, and arterial pressure during mild surface cooling: factors in mortality from coronary and cerebral thrombosis in winter. *BMJ* 1984;289:1405-8.

34. Stout RW, Crawford VL, McDermott MJ, Rocks MJ, Morris TC. Seasonal changes in haemostatic factors in young and elderly subjects. *Age Ageing* 1996;25:256-8.

35. Brennan PJ, Greenberg G, Miall WE, Thompson SG. Seasonal variation in arterial blood pressure. *BMJ* 1982;285:919-23.

36. van der Bom JG, de Maat MP, Bots ML, Hofman A, Kluft C, Grobbee DE. Seasonal variation in fibrinogen in the Rotterdam Study. *Thromb Haemost* 1997;78:1059-62.

37. Rose G. Seasonal variation in blood pressure in man. *Nature* 1961;189:235.

38. Woodhouse PR, Khaw KT, Plummer M. Seasonal variation of blood pressure and its relationship to ambient temperature in an elderly population. *J Hypertens* 1993;11:1267-74.

4
Socioeconomic status and cardiovascular disease

4.1 Socioeconomic status and aortic atherosclerosis. The Rotterdam Study

4.1.1 Abstract

Background. An inverse association has been reported between socioeconomic status and cardiovascular morbidity and mortality. Studies on subclinical manifestations of atherosclerotic diseases are limited and have not been carried out among elderly persons. We investigated the relationship between socioeconomic status and aortic atherosclerosis among elderly people.

Methods. As part of the Rotterdam Study, data on socioeconomic status and atherosclerosis were collected for 4,452 persons (age range 55-94 years). Atherosclerosis was estimated by calcified deposits in the abdominal aorta.

Results. Aortic atherosclerosis was more common among women in the lower educational and occupational strata. The lowest educated group and the lowest occupation group had increased risks of aortic atherosclerosis compared to the highest groups (odds ratios were 1.3 (95% confidence interval 1.0-1.6) and 1.3 (1.0-1.8) respectively). The odds ratios for severe atherosclerosis for women in the lowest socioeconomic strata compared to the highest strata were 1.6 (1.0-2.7) for education, 2.8 (1.1-7.5) for occupation and 1.7 (0.9-3.3) for income. After exclusion of persons with a history of cardiovascular disease, the same trends still emerged. Among men no relationships were observed.

Conclusions. These findings show that socioeconomic status is related to aortic atherosclerosis in women. This suggests that socioeconomic status affects the incidence of cardiovascular disease before its clinical manifestation.

4.1.2 Introduction

In several countries, cardiovascular morbidity and mortality rates have been reported to be inversely related with indicators of socioeconomic status.[1] Many studies have focussed on socioeconomic differences in advanced clinical signs, such as cardiovascular mortality or cardiovascular morbidity. However, it would also be informative to investigate the association between socioeconomic status and presence of atherosclerosis before the clinical appearance of disease. To our knowledge, the association between socioeconomic status and atherosclerosis has been investigated in two other studies, which measured atherosclerosis on the basis of intima-media thickness of the carotid artery.[2,3] In the present study, we investigated the relationship between socioeconomic status and aortic atherosclerosis, measured with aortic calcification, which represents an advanced stage of intima atherosclerosis and has been shown to predict clinically manifest atherosclerotic disease in the cardiac, cerebral and peripheral arterial circulation.[4,5] Aortic calcification may therefore be an indicator of generalised atherosclerosis. In addition, the presence of aortic calcified plaques may be directly related to the development of athero-thrombotic diseases, as aortic plaques might be an embolic source.[6]

We examined the presence and severity of aortic atherosclerosis in older subjects by indicators of socioeconomic status. Furthermore, we examined whether differences in aortic atherosclerosis between socioeconomic groups could be explained by the presence of classic cardiovascular risk factors.

4.1.3 Subjects and methods

Study population

The present study is part of the Rotterdam Study, a prospective cohort study among 7983 persons aged 55 and over at the time of the baseline examination (1990-1993) and who live in one defined geographic area in Rotterdam, The Netherlands. The rationale and design of the study have been described previously.[7] In short, the objective of the Rotterdam Study is to investigate determinants of chronic and disabling cardiovascular, neurogeriatric, locomotor, and ophthalmologic diseases. Data on aortic atherosclerosis were obtained during the second phase of the Rotterdam Study (1993-1994). Between the first and second phase of the study, 10% subjects died and 11% had refused to participate to the second phase. From those who attended the second phase, aortic calcification could not be assessed for subjects living in an institute (6%). For another 24%, data was not available due to logistic reasons (e.g. no personnel or x-ray equipment available). Data on aortic atherosclerosis were obtained for 2,550 and 1,901 non-institutionalised women and men. 2,537 women and 1,891 men were included in the analysis for education, 2,364 women and 1,837 men were included in the analysis for occupation, and 2,318 women and 1,715 men in the analysis for income, depending on the availability of the relevant information on socioeconomic status. The study has been approved by the Medical Ethics Committee of Erasmus University. Written informed consent was obtained from all participants.

Measurements

Education Information on socioeconomic status was obtained by trained interviewers during the baseline home interview at home. The levels of education attained were classified into three categories: primary education; lower/intermediate general and lower vocational education; higher general education, intermediate/higher vocational education and university.

Occupation Current occupation (14%), or for those who were not working anymore most recent occupation (86%), was classified according to the international Erikson-Goldthorpe-Portocarero scheme.[8,9] We distinguished three levels: higher and lower grade professionals; routine non-manual employees; and skilled and unskilled manual workers. 150 small entrepreneurs were excluded because of the small numbers.

Income Participants classified their household income in 13 pre-coded categories. As in some households more than one person may be dependent on one household income, the midpoint of each category was divided by the number of persons who were living from that income to the power 0.36.[10] The result of this transformation provides what is called the 'equivalent household income'. Four categories of equivalent household income were defined, corresponding approximately to quartiles of the distribution of the total population.

Aortic atherosclerosis Degree of aortic atherosclerosis was assessed with radiographic measurement of calcified deposits in the abdominal aorta. At the clinical health examination, a lateral abdominal film was made at a fixed distance while the subject was seated. Calcifications in the abdominal aorta were considered to be present when linear densities were seen in an area parallel and anterior to the lumbar spine (L1-L4).[5] The degree of aortic atherosclerosis was classified into five categories based on the length of the area involved. For the present analysis the data were aggregated into three categories, 'no', 'mild (one plaque, involved area 0.5 cm-1.0 cm)/moderate' (more plaques, involved area < 5.0 cm), and 'severe' (involved area ≥ 5.0 cm).

History of cardiovascular disease Participants were considered to have a history of cardiovascular disease when they had a self-reported history of myocardial infarction, stroke, coronary artery bypass surgery, or percutaneous transluminal angioplasty at the time of the baseline examinations or during the follow-up until the measurement of aortic atherosclerosis was assessed. In total 182 women and 356 men had a history of cardiovascular disease. In a subanalysis, persons with a history of cardiovascular disease were excluded. This may give more direct information on the putative 'causal' association between socioeconomic status and atherosclerosis and exclude the possibility that this association can be explained by health-related social mobility. Health-related social mobility implies that people drift down the social scale because of their health problems or move up because of their good health.

Risk factors Cardiovascular risk factors are often mentioned as the mediators through which socioeconomic status is related to cardiovascular disease. During the first phase of the study, several risk factors were assessed, i.e. blood pressure, smoking habits, alcohol

Table 4.1.1 Distribution of age, aortic atherosclerosis, and presence of a history of cardiovascular disease by socioeconomic status in Dutch elderly people.

	n	Age in years Mean (SD)	Aortic atherosclerosis in %			History of CVD* in %
			No	Mild	Severe	
Women						
Education						
University to intermediate vocational education	680	65.7 (7.1)	48.8	45.6	5.6	8.1
Lower/intermediate general and lower vocational education	811	66.2 (7.1)	46.0	48.1	5.9	5.3
Primary education	1,046	69.5 (8.0)	36.4	53.8	9.8	8.0
Occupation						
Professionals	267	66.3 (7.2)	49.1	47.2	3.7	6.7
Routine non-manual employees	1,113	66.2 (7.3)	45.3	51.3	7.1	6.1
Manual workers	908	68.8 (8.1)	38.7	53.1	8.3	9.1
Equivalent household income						
> 1,495 US$ per month	513	65.5 (6.6)	50.7	46.2	3.1	4.9
> 1,116 US$ - ≤ 1,495 US$ per month	650	68.0 (7.4)	44.6	49.2	6.2	5.7
> 853 US$ - ≤ 1,116 US$ per month	503	70.5 (7.3)	37.0	53.9	9.1	8.4
≤ 853 US$ per month	652	70.8 (7.9)	37.7	51.4	10.9	10.0
Men						
Education						
University to intermediate vocational education	1,019	65.9 (6.6)	40.9	52.6	6.5	18.1
Lower/intermediate general and lower vocational education	445	66.7 (6.9)	43.1	53.5	3.4	16.4
Primary education	427	68.7 (7.8)	37.2	56.0	6.8	23.2
Occupation						
Professionals	668	65.6 (6.8)	41.5	52.7	5.8	17.7
Routine non-manual employees	501	67.4 (7.0)	38.9	55.7	5.4	20.8
Manual workers	594	67.4 (7.3)	41.4	52.7	5.9	19.5
Equivalent household income						
> 1,495 US$ per month	559	64.0 (6.1)	43.6	51.2	5.2	14.8
> 1,116 US$ - ≤ 1,495 US$ per month	617	67.0 (6.6)	38.1	56.2	5.7	19.2
> 853 US$ - ≤ 1,116 US$ per month	327	68.9 (7.3)	39.8	53.8	6.4	23.5
≤ 853 US$ per month	212	71.4 (7.5)	43.6	54.2	6.6	25.4

SD Standard deviation.

* History of myocardial infarction, stroke, coronary artery bypass surgery, or percutaneous transluminal angioplasty.

consumption, body mass index and serum cholesterol. Systolic blood pressure was assessed at one occasion, on the right upper arm, twice in sitting position with a random-zero-sphygmomanometer.

Smoking history was assessed during an interview at home and categorised into former, never been or current smoker with the number of packyears. Alcohol consumption was assessed with a semiquantitative food frequency questionnaire. Body mass index was calculated by dividing weight by squared height. Height was measured with a scale (cm) standing upright, without shoes, heels together and head in Frankfurt plane; weight was measured with a balance in 0.1-kg standing upright in light clothes and without shoes. In addition, serum total cholesterol was determined by an automated enzymatic procedure in a non-fasting blood sample. High-density lipoprotein cholesterol was measured after precipitation of the non-HDL fraction with phospotungstate-magnesium.

Data analysis

To assess the association between socioeconomic status and presence of aortic atherosclerosis and 'severe' aortic atherosclerosis, age-adjusted (nine 5-year age groups) logistic regression analyses were done. In the analyses with presence of any aortic atherosclerosis, the categories of 'mild/moderate' and 'severe' aortic atherosclerosis were combined. The highest socioeconomic groups were taken as reference groups. The same analyses were performed excluding subjects with a history of cardiovascular disease. In a secondary analysis further adjustment were made for other cardiovascular risk factors. Statistical testing for trend was done with logistic regression where socioeconomic status was included in the model as a continuous variable (values 1, 2, 3, etc). Analyses were performed for women and men separately. All analyses were performed using the BMDP-package.[11]

4.1.4 Results

General characteristics The distribution of aortic atherosclerosis, age, and prevalence of cardiovascular disease by socioeconomic status are shown in Table 4.1.1. Women were more often classified in lower socioeconomic groups than men were. Lower socioeconomic groups were on average older than higher socioeconomic groups. The age distribution over socioeconomic groups was similar for women and men. Among men, cardiovascular disease was more common than among women. Aortic calcified plaques were present in a considerable part of the population, in about 60%. Among women, aortic calcified plaques were more common in the lower socioeconomic groups.

Aortic atherosclerosis In Tables 4.1.2 to 4.1.4, age-adjusted odds ratios are given for the association between socioeconomic status and aortic atherosclerosis. Among women, aortic atherosclerosis was more common in lower educational and occupational strata.

Table 4.1.2 Odds ratios for aortic atherosclerosis for educational groups (and 95% confidence intervals) in Dutch elderly people.

	Any aortic atherosclerosis						Severe aortic atherosclerosis					
	Whole sample		Whole sample without cases with a history of CVD†		Whole sample, without cases with a history of CVD†, adjusted for risk factors‡		Whole sample		Whole sample, without cases with a history of CVD†		Whole sample, without cases with a history of CVD†, adjusted for risk factors‡	
Education	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*
Women												
University to intermediate vocational education	1		1		1		1		1		1	
Lower/intermediate general and vocational education	1.1	0.9-1.3	1.1	0.9-1.4	1.2		1.1	0.9-2.2	1.3	0.7-2.3	1.3	
Primary education	1.3	1.0-1.6	1.3	1.0-1.6	1.2	0.9-1.5	1.4	0.7-1.8	1.6	1.0-2.7	1.6	0.7-2.4
P-trend	0.03		0.03		0.11	1.0-1.5	0.15		0.07		0.09	0.9-2.8
Men												
University to intermediate vocational education	1		1		1		1		1		1	
Lower/intermediate general and lower vocational education	0.9	0.7-1.1	0.9	0.7-1.2	0.9	0.7-1.2	0.4	0.2-0.8	0.5	0.2-1.0	0.5	0.2-1.1
Primary education	1.0	0.8-1.3	1.1	0.9-1.5	1.1	0.8-1.5	1.0	0.6-1.6	0.8	0.4-1.6	0.9	0.5-1.8
P-trend	0.98		0.46		0.57		0.44		0.31		0.51	

OR Odds ratio.
CI Confidence interval.
* Adjusted for age.
† History of myocardial infarction, stroke, coronary artery bypass surgery, or percutaneous transluminal angioplasty.
‡ Risk factors: blood pressure, smoking history, alcohol intake, body mass index and serum total and high-density lipoprotein cholesterol.

Table 4.1.3 Odds ratios for aortic atherosclerosis for occupational groups (and 95% confidence intervals) in Dutch elderly people.

	Any aortic atherosclerosis						Severe aortic atherosclerosis					
	Whole sample		Whole sample without cases with a history of CVD†		Whole sample, without cases with a history of CVD†, adjusted for risk factors‡		Whole sample		Whole sample, without cases with a history of CVD†		Whole sample, without cases with a history of CVD†, adjusted for risk factors‡	
Occupation	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*
Women												
Professionals	1		1		1		1		1		1	
Routine non-manual employees	1.2	0.9-1.6	1.2	0.9-1.6	1.1	0.8-1.5	1.9	0.9-4.0	3.2	1.2-8.4	3.1	1.1-8.4
Manual workers	1.3	1.0-1.8	1.3	1.0-1.8	1.2	0.9-1.7	2.1	1.0-4.4	2.8	1.1-7.5	2.7	1.0-7.6
P-trend	0.07		0.07		0.18		0.32		0.22		0.33	
Men												
Professionals	1		1		1		1		1		1	
Routine non-manual employees	1.0	0.8-1.3	1.1	0.8-1.4	1.1	0.8-1.4	0.8	0.5-1.4	0.9	0.4-1.7	0.9	0.4-1.7
Manual workers	0.9	0.7-1.2	1.0	0.7-1.2	1.0	0.7-1.3	0.8	0.5-1.3	0.8	0.4-1.5	0.8	0.4-1.5
P-trend	0.50		0.80		0.81		0.43		0.50		0.50	

OR Odds ratio.

CI Confidence interval.

* Adjusted for age.

† History of myocardial infarction, stroke, coronary artery bypass surgery, or percutaneous transluminal angioplasty.

‡ Risk factors: blood pressure, smoking history, alcohol intake, body mass index and serum total cholesterol.

Table 4.1.4 Odds ratios for aortic atherosclerosis for income levels (and 95% confidence intervals) in Dutch elderly people.

Equivalent household income per month	Any aortic atherosclerosis						Severe aortic atherosclerosis					
	Whole sample		Whole sample, without cases with a history of CVD†		Whole sample, without cases with a history of CVD†, adjusted for risk factors‡		Whole sample		Whole sample, without cases with a history of CVD†		Whole sample, without cases with a history of CVD†, adjusted for risk factors‡	
	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*	OR*	*95%-CI*
Women												
> 1,495 US$	1		1		1		1		1		1	
> 1,116 US$ - ≤ 495 US$	1.0	0.7-1.3	1.0	0.8-1.3	1.3	0.8-1.3	1.5	0.8-2.9	1.5	0.8-3.0	1.4	0.7-2.9
> 853 US$ - ≤ 1,116 US$	1.1	0.8 1.5	1.1	0.8 1.4	1.1	0.8-1.4	1.8	0.9-3.4	1.8	0.9-3.6	1.5	0.7-3.1
≤ 853 US$	1.0	0.8-1.4	0.9	0.7-1.2	0.9	0.7-1.2	2.0	1.0-3.6	1.7	0.9-3.3	1.5	0.8-3.1
P-trend	0.71		0.66		0.60		0.04		0.17		0.31	
Men												
> 1,495 US$	1		1		1		1		1		1	
> 1,116 US$ - ≤ 495 US$	1.1	0.9-1.4	1.1	0.8-1.4	1.1	0.8-1.4	1.1	0.6-1.7	0.8	0.4-1.5	0.8	0.4-1.7
> 853 US$ - ≤ 1,116 US$	0.9	0.7-1.2	0.9	0.7-1.3	1.0	0.7-1.4	0.9	0.5-1.7	0.8	0.4-1.7	0.9	0.4-1.9
≤ 853 US$	0.8	0.6-1.2	0.8	0.6-1.4	0.9	0.6-1.4	0.8	0.4-1.7	0.5	0.2-1.3	0.5	0.2-1.4
P-trend	0.30		0.52		0.72		0.59		0.19		0.25	

OR Odds ratio.
CI Confidence interval.
* Adjusted for age.
† History of myocardial infarction, stroke, coronary artery bypass surgery, or percutaneous transluminal angioplasty.
‡ Risk factors: blood pressure, smoking history, alcohol intake, body mass index and serum total cholesterol.

The odds ratio for any aortic atherosclerosis was 1.3 (95% confidence interval (CI) 1.0-1.6) for the lowest educated women, and 1.3 (95%-CI 1.0-1.8) for the lowest occupational class compared to the higher socioeconomic groups. Equivalent household income was not associated with presence of any aortic atherosclerosis in women. Among men, no relationships emerged between education, occupation or equivalent household income and aortic atherosclerosis. After exclusion of persons with a history of cardiovascular disease, the associations for both women and men did not change. For women without a history of cardiovascular disease, the odds ratios for severe aortic atherosclerosis for the lowest socioeconomic strata compared to the highest strata were 1.6 (95%-CI 1.0-2.7) for education, 2.8 (95%-CI 1.1-7.5) for occupation, and 1.7 (95%-CI 0.9-3.3) for income.

Risk factors for cardiovascular disease may explain the differences between the socioeconomic strata as they were found to vary by the several socioeconomic strata.[1] When the associations were adjusted for cardiovascular risk factors, i.e. blood pressure, smoking history, alcohol intake, body mass index, serum total cholesterol and high-density lipoprotein cholesterol, the findings in men remained almost unchanged (Table 4.1.2 to Table 4.1.4). For women, the odds ratios were only slightly reduced.

4.1.5 Discussion

The results of this study demonstrate that aortic atherosclerosis is more common among women in lower educational and occupational strata compared to women in higher strata. The associations could hardly be explained by the differences in major classic risk factors for cardiovascular disease. Among men, no socioeconomic differences in the presence of aortic atherosclerosis were found.

Before interpreting these findings, some methodological issues need to be addressed. First, the potential for selective participation needs to be considered. It is likely that the population represents a relatively healthy cohort, as persons with health problems are less able to participate in the follow-up study.[12,13] In our study, this mechanism of selective participation might have played a role at baseline of the study and for the population in which atherosclerosis is measured. Comparing our study population with the total population at baseline, subjects in the lower socioeconomic strata, women, and older persons were less likely to be in our sample for these analyses. They did not participate because they died between the first and second phase of the study, they had refused to participate, or they were living in an institution. On the one hand such a selection could have influenced descriptive data, but hardly the strength of the associations. On the other hand, it could be that the more susceptible persons dropped out; the association between socioeconomic status and aorta calcification might have been stronger among those who did not participate because of illness or death, compared to the association among those who participated in our study. We expect that if anything such selection has led to an underestimation of the association between socioeconomic status and aortic calcification.

Secondly, the nature of the measurements of atherosclerosis and socioeconomic status needs to be considered. The validity of radiological assessment of aortic calcification for the diagnosis of aortic atherosclerosis was shown by Hyman and Epstein using necropsy material and by Witteman et al using computed tomography.[14,15] Comparison with computed tomography assessments showed that calcifications detected by radiography were located in the vessel.[14,15] The detection method has shown to be highly specific, and in most cases visible calcification represented advanced atherosclerosis.[14,15] Minor stages of atherosclerosis will not be detected, because aortic calcification is quite a conservative measure of atherosclerosis. Misclassification in our study, however, would be independent of socioeconomic status; the observed associations may therefore have underestimated the true effects. The presence of calcified plaques in the abdominal aorta is a predictor of cardiovascular morbidity and mortality[4,5] and is associated with major cardiovascular risk factors.[15,16] In addition, aortic atherosclerosis is positively related to increased intima-media thickness of the carotid arteries.[16] This suggests an association between aortic atherosclerosis and atherosclerosis in other areas of the body.[17] Thus, the presence of aortic calcified plaques can be seen as a measurement of generalised atherosclerosis.

Information bias in the measurement of socioeconomic status was minimised by gathering this information in a standardised way. However, in older subjects assessment of socioeconomic status may pose specific difficulties. For instance, although educational level remains relatively stable throughout time, it may be subject to cohort effects. Also, social status of a certain occupation may not always have been constant as society's structure changes with time.[18] These problems are addressed by including age in the multivariate analyses. A disadvantage of the measurement of income, especially for women, is that it may be affected by a recent divorce or spouse's death. It is unclear in what way such misclassification of socioeconomic status could have affected the results.

To our knowledge, this study is the first one to examine the relationship between socioeconomic status and atherosclerosis in elderly men and women. Some studies examined this relationship in younger populations using ultrasonographic techniques. Lynch et al reported a strong association between socioeconomic status and atherosclerosis and progression of artherosclerosis, measured by intima-media thickness, in an unselected population of middle- aged men.[3,19] Diez-Roux et al reported an increasing carotid wall thickness with decreasing income and education and an increased carotid wall thickness in lower occupational categories for both women and men.[2] There could be several explanations for the differences between the findings of these studies and our weaker associations. First, our findings may be weaker due to the older population, which results in misclassification of socioeconomic status as mentioned above. Furthermore, it is likely that socioeconomic differences would diminish with age due to selective mortality, e.g. that persons with aortic plaques associated with low socioeconomic status may have died before they could participate in the study. In this respect, it is plausible that selective mortality amongst the male survivors might be larger than among women since more middle-aged men died of cardiovascular disease. This might explain the lack of association among men. However, we do not believe that the differences between men and women can be fully ascribed to differences in selective mortality. Alternatively, the differences between men and women and between our findings and findings from other studies may reflect differences between aortic atherosclerosis and atherosclerosis in other areas of the body. It may be that there are sex-specific localising features for arterial calcification. Women seem to have a predominance of aortic atherosclerosis while men may be more prone to coronary calcification.[5,20-23] This suggests that the measurement of aortic atherosclerosis may be of greater relevance in women.

Health-related social mobility and intermediary factors may explain socioeconomic health differences.[24] Health-related social mobility implies that people drift down the social scale because of their health problems or move up because of their good health. Because aortic atherosclerosis is non-symptomatic, the association between socioeconomic status and atherosclerosis is not likely to be affected by social mobility. Moreover, the measurement of education and occupation represents the socioeconomic status of decades ago, and is therefore unlikely to be affected by the atherosclerotic status. Finally, exclusion of subjects with a history of cardiovascular disease gave similar results. Hence, health selection does not appear to explain the observed socioeconomic differences in atherosclerosis. The question remains how socioeconomic status is related to aortic atherosclerosis. In our study, conventional cardiovascular risk factors could hardly explain the findings among women. It is possible that other unmeasured risk factors explain the differences. Also, it is feasible that risk factors measured at an earlier age may have had a larger impact. The mechanisms of the relationship of socioeconomic status to aortic atherosclerosis require further study.

In conclusion, our findings that socioeconomic status is related to the presence and severity of atherosclerosis in women suggest that socioeconomic status may affect the risk of cardiovascular disease through atherosclerosis and thus before its clinical manifestation. The mechanisms which can explain the association among older subjects remain to be established.

4.1.6 References

1. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.

2. Diez-Roux AV, Nieto FJ, Tyroler HA, Crum LD, Szklo M. Social inequalities and atherosclerosis. The atherosclerosis risk in communities study. *Am J Epidemiol* 1995;141:960-72.

3. Lynch J, Kaplan GA, Salonen R, Cohen RD, Salonen JT. Socioeconomic status and carotid atherosclerosis. *Circulation* 1995;92:1786-92.

4. Witteman JC, Kannel WB, Wolf PA, Grobbee DE, Hofman A, D'Agostino RB, Cobb JC. Aortic calcified plaques and cardiovascular disease (the Framingham Study). *Am J Cardiol* 1990;66:1060-4.

5. Witteman JC, Kok FJ, van Saase JL, Valkenburg HA. Aortic calcification as a predictor of cardiovascular mortality. *Lancet* 1986;2:1120-2.

6. Karalis DG, Chandrasekaran K, Victor MF, Ross JJ, Mintz GS. Recognition and ebolia potential of intraortic atherosclerotic debris. *J Am Coll Cardiol* 1991;17:73-8.

7. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

8. Erikson E, Goldthorpe JH. *The constant flux*. Oxford: Clarendon Press, 1992.

9. Ganzeboom HBG, Luijkx R, Treiman DJ. Intergenerational class mobility in comparative perspective. *Res Social Stratification Mobility* 1989;8:3-84.

10. Buhmann B, Rainwater L, Schmaus G, Smeeding TM. Equivalence scales, well-being, inequality, and poverty: sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) data base. *Review of Income and Wealth* 1988;2:115-42.

11. Dixon WJ, ed. *BMDP Statistical Software Manual.* Berkeley: University of California Press, 1990.

12. Herzog AR, Rodgers WL. Age and response rates to interview sample surveys. *J Gerontol* 1988;43:S200-5.

13. Kelsey JL, O'Brien LA, Grisso JA, Hoffman S. Issues in carrying out epidemiologic research in the elderly. *Am J Epidemiol* 1989;130:857-66.

14. Hyman JB, Epstein FH. A study of the correlation between roentgenographic and post-mortem calcification of the aorta. *Am Haert J* 1954;47:540-3.

15. Witteman JC, Grobbee DE, Valkenburg HA, van Hemert AM, Stijnen T, Burger H, Hofman A. J-shaped relation between change in diastolic blood pressure and progression of aortic atherosclerosis. *Lancet* 1994;343:504-7.

16. Bots ML, Witteman JC, Grobbee DE. Carotid intima-media wall thickness in elderly women with and without atherosclerosis of the abdominal aorta. *Atherosclerosis* 1993;102:99-105.

17. Bots ML, Hoes AW, Koudstaal PJ, Hofman A, Grobbee DE. Common carotid intima-media thickness and risk of stroke and myocardial infarction. The Rotterdam Study. *Circulation* 1997;96:1432-7.

18. Dronkers J, Ultee WC, ed. *Verschuivende ongelijkheid in Nederland. Sociale gelaagdheid en mobiliteit [in Dutch].* Assen: Van Gorcum, 1995:335.

19. Lynch J, Kaplan GA, Salonen R, Salonen JT. Socioeconomic status and progression of carotid atherosclerosis. Prospective evidence from the Kuopio Ischemic Heart Disease Risk Factor Study. *Arterioscler Thromb Vasc Biol* 1997;17:513-9.

20. Danielsen R, Sigvaldason H, Thorgeirsson G, Sigfusson N. Predominance of aortic calcification as an atherosclerotic manifestation in women: the Reykjavik study. *J Clin Epidemiol* 1996;49:383-7.

21. World Health Organisation. Atherosclerosis of the aorta and coronary arteries in five towns. *Bull WHO* 1976;53:485-654.

22. Sternby NH. Atherosclerosis in a defined population. An autopsy survey in Malmo, Sweden. *Acta Pathol Microbiol Scand* 1968;194:1-216.

23. The geograhical pathology of atherosclerosis. *Lab Invest* 1968;1968:3-180.

24. Townsend P, Davidson N, Whitehead M, ed. *Inequalities in health (The Black Report & The health Divide).* London: Penguin Books, 1988.

4.2 Socioeconomic status and stroke among Dutch elderly women. The Rotterdam Study

4.2.1 Abstract

Background. To assess the association between socioeconomic status and the risk of having a stroke among elderly women.

Methods. The association between socioeconomic status and stroke emerged in cross-sectional and longitudinal data on 4,274 female participants of the Rotterdam Study, a prospective population-based follow-up study in The Netherlands among older subjects.

Results. A history of stroke was more common among women in lower socio-economic strata. The same trend was observed for the relationship between the lowest socioeconomic groups and the incidence of stroke. Risk factors for stroke were not related to socioeconomic status in a consistent manner. Smoking, a history of cardiovascular disease, and overweight were more common in lower socioeconomic groups. However, socioeconomic differences in hypertension, anti-hypertensive drug use, prevalence of atrial fibrillation and prevalence of left ventricular hypertrophy were not observed. The complex of established risk factors could only partly explain the association between socioeconomic status and stroke.

Conclusions. There is a strong association among elderly women between socioeconomic status and stroke. The association could only partly be explained by known risk factors. Our findings indicate that not only the actual risk profile but also risk factors earlier in life may be of importance.

4.2.2 Introduction

Stroke is a major contributor to cardiovascular mortality and one of the most important causes of disability in The Netherlands.[1] Several studies have shown that people with a lower socioeconomic status are at greater risk of cardiovascular morbidity and mortality.[2] The lower socioeconomic groups also appear to have more risk of dying of a stroke.[3-15] Most of the evidence for the association between socioeconomic status and stroke is based on studies of stroke mortality and its geographical variation.[4,10-15] Studies on this association at an individual level have been performed mainly among middle-aged men. Because cardiovascular morbidity and mortality generally decrease in younger age groups and an increasing proportion of the population reaches advanced age, health inequalities among elderly people are an important public health concern. This applies especially to women, because in contrast to coronary heart disease, stroke together with its associated invalidity is in absolute numbers more pronounced among older women than among men.[16]

We examined the association between indicators of socioeconomic status and the prevalence and incidence of stroke among elderly women. We also studied the association between socioeconomic status and the main risk factors for stroke among elderly women.

4.2.3 Subjects and methods

Study population

The Rotterdam Study is a prospective population-based follow-up study of the determinants of chronic and disabling cardiovascular, neurogeriatric, locomotor- and ophthalmologic diseases among persons aged 55 years and over, living in one defined geographic area in Rotterdam, The Netherlands.[17] The present analysis focuses on female participants, 4,878 women in total (response rate = 77%) at baseline. Of these women, 188 (4%) did not sign an informed consent to allow collection of data from their medical records. In addition, at the time of this analysis, 416 persons had not (yet) been completely followed up because of link-up problems between their general practitioners' medical records on their and our computerised registration system. Thus, on April 1st 1996, completed follow-ups were available for 4,274 women, covering an average period of 4.0 (SD 0.8) years.

Measurements

Trained interviewers obtained information on education, occupation and income as indicators of socioeconomic status during a home visit, at baseline of the study (1990-1993).

Education The participants were asked about their formal education, the number of years in each type of education and whether education had been completed. From this information the attained highest level of education was defined and classified into four categories: primary education; lower/intermediate general and lower vocational education; higher general and intermediate vocational education; higher vocational education and university.

Occupation For this analysis we classified women on the basis of the current or last occupation of the head of the household. Partners were assumed to be head of the household when women lived with a partner or were widowed. We assume that this is a plausible assumption for our elderly population. Other women, divorced or without partner, were themselves considered to be head of the household. The classification was set up according to the international Erikson-Goldthorpe-Portocarero scheme.[18,19] Four levels are distinguished: higher and lower grade professionals; routine non-manual employees; small entrepreneurs; and manual workers.

Household income Income represents mainly the material dimension of socioeconomic status, therefore, it is likely that this is determined by the income of the whole household. Household income was classified into 13 pre-coded categories. Equivalent household income was computed by dividing the midpoint of each household income category by the number of persons living on that income to the 0.36 power.[20] Institutionalised participants were excluded from the analysis (n=493) because their financial situation differs from that of non-institutionalised participants. Four categories of equivalent household income were defined, corresponding to approximately to quartiles of the distribution of the total non-institutionalised population.

Data on education, occupation, and income was missing for 4%, 8%, and 11% of the participants respectively.

Stroke Participants were considered to have a history of stroke on the basis of self-reported history of stroke at the time of baseline measurements. This was confirmed by data from medical records of the general practitioner or neurologist involved. Of the 4,274 women, 112 appeared to have a history of stroke.

Detailed information on incident cases of stroke and on vital status was obtained from participants' general practitioners. Most general practitioners involved have their practice computerised and digital information on, among other events, all possible incident cases of stroke and deaths is sent regularly to the Rotterdam research centre. Information on vital status was also obtained from the Rotterdam municipal authorities. When a stroke or death was reported, additional information was obtained by interviewing the relevant general practitioner and by consulting hospital discharge records in case of admittance or referral. Information was furthermore retrieved by research physicians from participants' medical records held at medical practices that were not linked up to the computer system. Two research physicians independently classified (e.g., date of event, certainty of diagnosis, ICPC-code or ICD-10 code) all suspected cases on the basis of all the available information. When they disagreed, the physicians would discuss the case until consensus was reached. Finally, a neurologist reviewed all suspected cerebrovascular cases and classified them into definite, probable and possible stroke. On April 1st 1996, 168 women were diagnosed as having had a first stroke (ICPC-code K90) in the follow-up period.

Risk factors Behavioural and physiological risk factors are often regarded as the mediators through which socioeconomic status is related to cardiovascular disease. Several risk factors were assessed in the baseline phase of the study. In this analysis, we focussed on the established risk factors for stroke, e.g. systolic blood pressure, hypertension, drug use for hypertension, atrial fibrillation, left ventricular hypertrophy, diabetes mellitus, body mass index and smoking.[21] Systolic and diastolic blood pressure were measured twice on one occasion, with participants sitting down, on their right upper arm, with a random-zero-sphygmomanometer. Hypertension was considered to be present with a systolic blood pressure of 160 mmHg or over, a diastolic blood pressure of 95 mmHg or over, or because of current anti-hypertensive drug use for the indication of hypertension. We assessed atrial fibrillation and left ventricular hypertrophy by electrocardiogram using an automatic diagnostic classification system. Smoking history was assessed during an interview at home and was categorised as never, former or current smoker. Body mass index was calculated by dividing weight by squared height. Plasma

Table 4.2.1 Risk of having a history of stroke by socioeconomic status, odds ratios and 95% confidence intervals, adjusted for age.

Socioeconomic status	n	No. of cases	Adjusted for age			Adjusted for age and risk factors*		
			OR	95%-CI	*P*-trend	OR	95%-CI	*P*-trend
Educational level								
Primary education	1,961	72	1		0.011	1		0.07
Lower/intermediate general education, lower vocational education	1,188	23	0.79	0.48-1.30		0.89	0.54-1.49	
Higher general education, intermediate vocational education	794	9	0.47	0.23-0.96		0.56	0.27-1.17	
University, higher vocational education	158	1	0.24	0.03-1.73		0.32	0.04-2.35	
Occupational level of head of the household								
Manual workers	1,507	57	1		0.18	1		0.51
Small entrepreneurs	224	10	1.21	0.60-2.44		1.25	0.60-2.60	
Routine non-manual employees	1,112	10	0.79	0.48-1.30		0.85	0.51-1.42	
Professionals	1,080	19	0.72	0.42-1.24		0.84	0.47-1.47	
Equivalent household income								
1st quartile	1,070	30	1		0.005	1		0.006
2nd quartile	819	17	0.80	0.44-1.47		0.72	0.38-1.35	
3rd quartile	862	10	0.55	0.26-1.17		0.53	0.24-1.16	
4th quartile	625	2	0.16	0.04-0.70		0.15	0.03-0.68	

OR Odds ratio.

CI Confidence interval.

* Adjusted for systolic blood pressure, hypertension, drug use for hypertension, smoking, cardiovascular disease, left ventricular hypertrophy, atrial fibrillation, diabetes mellitus, fibrinogen, body mass index and alcohol consumption.

fibrinogen levels were determined according to Clauss.[22] Diabetes was considered to be present when subjects were on oral blood glucose lowering drugs or received insulin treatment. Participants were considered to have a history of cardiovascular disease when they had a self-reported history of myocardial infarction, coronary artery bypass surgery, angina pectoris, intermittent claudication or percutaneous transluminal angioplasty at the time of the baseline examinations. Alcohol intake and other dietary factors were assessed with a semiquantitative food frequency questionnaire.[23]

Data analysis

Our data analysis approach was threefold. First, logistic regression analyses were performed to explore the relationship between socioeconomic status and history of stroke at baseline. To examine the association between socioeconomic status and incidence of stroke, Cox' proportional hazard regression analyses were applied, excluding all women with a history of stroke at baseline. The individual follow-up period was defined as the period between the first home interview until date of incident stroke, until date of death, or until April 1st 1996. Secondly, age-adjusted means and proportions of risk factors according to socioeconomic groups were computed on the basis of analysis of covariance or logistic regression analysis. Finally, the associations between socioeconomic status and stroke were adjusted for these risk factors by adding them to the regression models. Missing values were included in the models by the indicator method.

In general, all analyses were age-adjusted (eight 5-year age groups). To obtain more stable estimates the lowest socioeconomic groups were used as reference groups, since the incidence of stroke in the highest groups was small. Statistical testing for trends was done with linear or logistic regression including education, occupation or income in the model as a continuous variable (values 1, 2, etc.). All analyses were performed with the statistical program SPSS.

4.2.4 Results

In our study population, the majority of women were classified in the lower socioeconomic groups (Table 4.2.1). At time of the baseline measurements only 7% were still employed. Most women were aged above 65 and already retired. On average, they had their last paid job 29 years ago. The majority of the women were or had been employed as manual worker (43%) or routine non-manual workers (43%). Six percent mentioned that they were never employed. The mean age at baseline of the study was 71 (SD 10) years. On average, subjects in lower socioeconomic groups were older than those in higher socioeconomic groups. For example, among women of 70 years and over, 29% had lower educational levels, as opposed to 10% for those who were not yet 70. In addition, the mean age of the stroke cases was higher than that of the non-cases. All analyses were therefore adjusted for age.

Table 4.2.2 Risk of first stroke by socioeconomic status, relative risks and 95% confidence intervals, adjusted for age.

		No. of cases	Adjusted for age			Adjusted for age and risk factors*		
Socioeconomic status	n		RR	95%-CI	*P*-trend	RR	95%-CI	*P*-trend
Educational level								
Primary education	1,889	97	1		0.32	1		0.53
Lower/intermediate general education, lower vocational education	1,165	32	0.81	0.54-1.22		0.86	0.57-1.30	
Higher general education, intermediate vocational education	785	27	1.08	0.70-1.67		1.17	0.75-1.82	
University, higher vocational education	157	1	0.18	0.02-1.28		0.19	0.03-1.36	
Occupational level of head of the household								
Manual workers	1,457	74	1		0.054	1		0.064
Small entrepreneurs	214	8	0.68	0.33-1.41		0.65	0.31-1.38	
Routine non-manual employees	1,088	46	1.02	0.71-1.48		1.05	0.72-1.52	
Professionals	1,061	24	0.60	0.38-0.96		0.59	0.37-0.95	
Equivalent household income								
1st quartile	1,040	53	1		0.12	1		0.14
2nd quartile	802	30	0.96	0.62-1.49		0.81	0.51-1.29	
3rd quartile	852	22	0.83	0.55-1.35		0.81	0.48-1.36	
4th quartile	623	8	0.55	0.25-1.16		0.57	0.26-1.24	

RR Relative risk.

CI Confidence interval.

* Adjusted for systolic blood pressure, hypertension, drug use for hypertension, smoking, cardiovascular disease, left ventricular hypertrophy, atrial fibrillation, diabetes mellitus, fibrinogen, body mass index and alcohol consumption.

History of stroke

Age-adjusted associations between socioeconomic status and history of stroke are shown in Table 4.2.1. A history of stroke was less common among the highest socioeconomic groups. The relative risk of having a history of stroke was 0.24 (95%-CI 0.03-1.73) for the most highly educated women, and 0.16 (95%-CI 0.04-0.70) for the highest income group compared to the lowest socioeconomic groups. Linear trends were statistically significant for education and income.

Incidence of stroke

In Table 4.2.2, age-adjusted relative risks of incidence of stroke with socioeconomic status are presented. Similar to the cross-sectional analyses, the highest socioeconomic groups also had a lower risk of stroke. However, statistical significance was only reached for the association between incidence of stroke and occupation of the head of the household. The intermediate educational and occupational groups did not differ in their risk of stroke compared to the lowest groups.

Risk factors for stroke

In Table 4.2.3 age-adjusted means and proportions of the main risk factors for stroke according to income are presented. The associations between the other indicators of socioeconomic status are not shown, but for those that are not mentioned specifically, findings were similar to the associations with income. Blood pressure and hypertension were not associated with socioeconomic status. However, smoking was more common in the lower socioeconomic groups compared to higher socioeconomic groups. A history of cardiovascular disease and diabetes mellitus was more frequent in the lower socioeconomic groups (this was not observed for educational level). For all three indicators of socioeconomic status, no associations were observed for left ventricular hypertrophy and atrial fibrillation. Similarly, there was no socioeconomic gradient for plasma fibrinogen levels, with the exception of a trend for education. Body mass index decreased with increasing socioeconomic status. Use of alcohol was positively associated with income.

To examine whether these risk factors could explain the association between incidence of stroke and socioeconomic status, the association between socioeconomic status and stroke was adjusted for these risk factors. The associations between socioeconomic status and stroke remained almost unchanged (see Tables 4.2.1 and 4.2.2). In addition, differences in other dietary factors, such as dietary fat consumption and antioxidants, could not explain the association between socioeconomic status and stroke [results not shown].

Table 4.2.3 Risk factors according to equivalent household income, adjusted for age (adjusted means and percentages).

Risk factor	Equivalent household income				Total		P-trend
	1st quartile *n=1,040*	2nd quartile *n=802*	3rd quartile *n=852*	4th quartile *n=623*	Mean	n*	
Systolic blood pressure (mmHg)	139.6	140.1	141.0	140.0	140.2	3,028	0.45
Hypertension (%)	34.9	36.4	38.0	33.7	35.8	3,030	0.93
On medication for hypertension (%)	20.2	23.6	24.2	19.1	21.9	2,676	0.79
Current smokers of cigarettes (%)	23.0	19.8	16.0	16.1	18.7	3,217	0.0001
Never smokers (%)	50.5	51.2	54.0	53.7	52.4	3,277	0.12
Cardiovascular disease† (%)	13.5	11.0	11.2	9.3	11.3	3,317	0.016
Left ventricular hypertrophy on ECG (%)	4.2	6.3	4.0	5.4	5.0	1,507	0.96
Atrium fibrillation (%)	1.4	1.0	1.8	1.3	1.4	1,552	0.76
Diabetes mellitus (%)	4.7	6.6	4.0	2.7	4.5	3,231	0.041
Fibrinogen, adjusted for use of vitamin K-antagonists (g/L)	2.78	2.88	2.78	2.78	2.81	1,438	0.80
Body mass index (kg/m^2)	26.9	27.2	26.6	26.3	26.8	3,052	0.005
Use of alcohol (%)	69.3	72.3	72.7	80.2	73.6	2,687	0.0002

* Not all risk factors are available for each participant.

† Self-reported history of myocardial infarction, coronary artery bypass surgery, angina pectoris, intermittent claudication, or percutaneous transluminal angioplasty.

4.2.5 Discussion

The results of our study suggest that stroke is substantially more common among women in the lower socioeconomic strata. In addition, the incidence of stroke is higher in the lower socioeconomic groups. However, risk factors were not associated with socioeconomic status in a consistent manner and could only partly explain the association between socioeconomic status and stroke.

A number of issues need to be addressed before results can be interpreted. First, selective participation must be considered. It is likely that the population represents a relatively healthy cohort, since people with health problems are less capable of visiting the research centre and thus less likely to participate in the study.[24,25] In addition, the exclusion of persons with incomplete follow-ups may have influenced the results. Most people that did not sign the informed consent were simply not able to do so due to their reduced cognitive function. These subjects were slightly older and had a lower socioeconomic status compared to the overall study population. Another cause for loss to follow-up, (i.e. link-up problems) was not associated with socioeconomic status (results not shown). In our opinion, selective participation has hardly influenced the results or, if anything, it has led to an underestimation of the real differences.

Second, the nature of measuring stroke, risk factors and socioeconomic status needs to be considered. Information bias in the measurement of socioeconomic status was minimised by collecting this information in a standardised manner. However, for older subjects, assessment of socioeconomic status may involve specific difficulties. For instance, although educational level remains relatively stable over time, it may be subject to cohort effects. Also, social status of a certain occupation may have changed over time because of changes in the structure of society.[26] These problems were solved by including age in the multivariate analyses. A disadvantage of measuring income is that it may be affected by a recent divorce or spouse's death. Such a misclassification of socioeconomic status may have led to an underestimation of the association between socioeconomic status and stroke. Although the indicators of socioeconomic status represent different dimensions of socioeconomic status, their associations with stroke were quite similar.

The measurement of stroke may have been affected by inaccuracies in general practitioners' diagnoses. A number of stroke cases may be assigned to other cardiovascular diseases whereas other diseases may have been wrongly coded as stroke. It is nevertheless unlikely that this has influenced our estimates to a large extent. Another source of bias lies in socioeconomic differences in use of health care facilities. It was found that people with a lower socioeconomic status more often consult a general practitioner than people whose socioeconomic status is higher, even with the illness taken into account.[27] For that reason, we decided not to exclude strokes that were less likely (possible) in the neurologists' opinion. Exclusion of these events would have resulted in bias, since the classification depends on whether an event has led to hospitalisation and the availability of information about signs and symptoms in patient records. Unfortunately, the number of strokes was too small for stratified analyses to be performed. In addition, it can be hypothesised that the proportion of strokes that go unnoticed by general practitioners is associated with socioeconomic status. However, this non-random misclassification will not be as large for socioeconomic differences in stroke, since all stroke patients in The Netherlands will be seen by a general practitioner because of the severity of this disease.

Furthermore, a limitation of our analyses is the relatively short follow-up period. As a result, the number of strokes might be too small to assess a significant association. However, the fact that a similar and statistically significant association between the socioeconomic status and history of stroke is observed, confirmed the inverse relationship between the lowest socioeconomic groups and stroke. Nevertheless, it is of concern that despite the larger number of events for incident disease relative to prevalent disease that the pattern of association, especially for the intermediate groups, is not as clear. The question arises whether the association between socioeconomic status and having a history of stroke might be biased, because women of a lower socioeconomic groups with a prevalent stroke might be more willing to participate in this study believing it to be a source of health care. However, in The Netherlands where health care is available for everybody, this is not a very likely explanation. Another explanation might be that the association between socioeconomic status and stroke declines with age.

Lastly, our study population was chosen in one quite homogenous region. The situation occurs that several intermediary factors, such as neighbourhood conditions, housing conditions or health care services are similar for everybody. Since these macrofactors also account for the socioeconomic inequalities in health in the total population,[28,29] part of the socioeconomic differences in health may not be detected in such a setting. The inequalities in stroke would probably be even larger when the socioeconomic groups vary also in these intermediary factors.

A number of studies have reported an inverse association between socioeconomic status and stroke.[3-15,30-32] However, most reports are based on geographic variation in occurrence of stroke by socioeconomic differences.[4,9,12-15,31] Nevertheless, a number of studies at the individual level observed a socioeconomic gradient in stroke, although these studies typically focussed on socioeconomic differences in risks to die from stroke among men and among younger age groups.[3,5-8,10,30,32] The present study is the first to describe socioeconomic differences in stroke morbidity among elderly women. Even though our study design and methods differ from previous studies, similar trends in the association between socioeconomic status and stroke risk were observed.

The observed trends are strong compared with those in previous studies. The study population only comprised persons of 55 years and older. On the one hand, socioeconomic differences at older ages may diminish compared to younger ages, because people from lower socioeconomic groups who live on into old age may represent a very healthy elite; less viable individuals may have died sooner.[33] However, this survival effect would be less among women because of a lower mortality rate at younger ages. On the other hand, older persons from lower socioeconomic groups are exposed for a longer time to factors that contribute to socioeconomic differences in health.[33] The accumulation of disadvantages over a person's course of life might result in larger socioeconomic differences at older ages.

In this study we focussed on the differences among women, since Dutch women suffer from stroke more than men do, and since less is known about socioeconomic inequalities among women. Nevertheless, data on socioeconomic differences in stroke for men was also available in the Rotterdam Study. For men, we found no association between socioeconomic status and history of stroke or incidence of stroke (results not shown). This difference between associations for men and women, or the difference with results from other studies among younger men could be caused by the fact that the survival effect is more pronounced among elderly men, resulting in smaller socioeconomic differences for stroke. A second cause might be that the distribution of risk factors may be different for men and women and for (younger) men in other countries. For example, hypertension, one of the major risk factors for stroke, was positively related with socioeconomic status among men in the Rotterdam Study (see Chapter 5.2).

We expected the established risk factors for stroke to explain at least part of the socioeconomic differences in stroke occurrence. However, in our study population, these risk factors may give some explanation for the higher incidence of stroke, but as in other studies, a large proportion of the socioeconomic influence remained unexplained. There are several explanations for this. First, in this study there were some significant socioeconomic differences in risk factors, such as smoking, diabetes, cardiovascular disease and elevated body mass index, but we did not observe socioeconomic differences in the main risk factors for stroke, such as hypertension, use of anti-hypertensive drugs, atrial fibrillation or left ventricular hypertrophy. These results contrast with most other studies on socioeconomic differences in risk factors, which makes further research necessary.[2,34-36] Second, it is well known that with increasing age established risk factors play a less important role. For example, in our study the regression coefficient of age is 50% higher than the coefficient in the risk profile of stroke, which is based on the Framingham Study based on a younger study population.[21] It is possible that at older ages the impact of risk factors on the explanation of socioeconomic differences in stroke may be different. Also, in the present setting, risk factors were measured by a single assessment at old age. It is possible that the impact of these risk factors on socioeconomic differences in stroke would be larger when measured earlier in life. Finally, it is possible that other unmeasured risk factors are better able to explain the differences. For example, Davey Smith suggested that risk factors earlier in life, such as birth weight or head circumference, which are both associated with socioeconomic status, are directly related to blood pressure and the occurrence of stroke in adult life.[14]

The large socioeconomic differences in stroke observed in this study warrant further research that focuses on changes in risk factors that are helpful in elucidating the aetiology of inequalities. These studies may provide information on potential interventions with respect to determinants of diseases and selection of risk groups to improve the overall health of a population and to reduce differences in health between socioeconomic groups in a society.

In conclusion, elderly women in the lowest socioeconomic groups have a higher risk of stroke compared to those in the higher socioeconomic groups. Established risk factors can only partly explain this association.

4.2.6 References

1. C.B.S. (Dutch Central Bureau of Statistics). *Statistisch Jaarboek 1997 [in Dutch]*. Voorburg/Heerlen: CBS, 1997.
2. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.
3. Khaw KT, Barrett-Connor E, Suarez L, Criqui MH. Predictors of stroke-associated mortality in the elderly. *Stroke* 1984;15:244-8.
4. Siegel PZ, Deeb LC, Wolfe LE, Wilcox D, Marks JS. Stroke mortality and its socioeconomic, racial, and behavioral correlates in Florida. *Public Health Rep* 1993;108:454-8.
5. Bennett S. Socioeconomic inequalities in coronary heart disease and stroke mortality among Australian men, 1979-1993. *Int J Epidemiol* 1996;25:266-75.
6. Marmot MG, Shipley MJ, Rose G. Inequalities in death-specific explanations of a general pattern? *Lancet* 1984;1:1003-6.
7. Lindenstrom E, Boysen G, Nyboe J. Lifestyle factors and risk of cerebrovascular disease in women. The Copenhagen City Heart Study. *Stroke* 1993;24:1468-72.
8. Heller RF, Williams H, Sittampalam Y. Social class and ischaemic heart disease: use of the male:female ratio to identify possible occupational hazards. *J Epidemiol Community Health* 1984;38:198-202.
9. Vågerö D, Norell SE. Mortality and social class in Sweden-exploring a new epidemiological tool. *Scand J Soc Med* 1989;17:49-58.
10. Modan B, Wagener DK. Some epidemiological aspects of stroke: mortality/morbidity trends, age, sex, race, socioeconomic status. *Stroke* 1992;23:1230-6.

11. Kunst AE, Looman CW, Mackenbach JP. Socio-economic mortality differences in The Netherlands in 1950-1984: a regional study of cause-specific mortality. *Soc Sci Med* 1990;31:141-52.

12. Maheswaran R, Elliott P, Strachan DP. Socioeconomic deprivation, ethnicity, and stroke mortality in Greater London and south east England. *J Epidemiol Community Health* 1997;51:127-31.

13. Casper M, Wing S, Strogatz D, Davis CE, Tyroler HA. Antihypertensive treatment and US trends in stroke mortality, 1962 to 1980. *Am J Public Health* 1992;82:1600-6.

14. Davey Smith G, Ben-Shlomo Y. Geographical and social class differentials in stroke mortality-the influence of early-life factors. *J Epidemiol Community Health* 1997;51:134-7.

15. Franks PJ, Adamson C, Bulpitt PF, Bulpitt CJ. Stroke death and unemployment in London. *J Epidemiol Community Health* 1991;45:16-8.

16. Bots ML, Looman SJ, Koudstaal PJ, Hofman A, Hoes AW, Grobbee DE. Prevalence of stroke in the general population. *Stroke* 1996;27:1499-1501.

17. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

18. Erikson R, Goldthorpe JH, Portocarero L. Intergenerational class mobility in three western countries: England, France and Sweden. *Br J Sociol* 1979;30:415-41.

19. Ganzeboom HBG, Luijkx R, Treiman DJ. Intergenerational class mobility in comparative perspective. *Res Social Stratification Mobility* 1989;8:3-84.

20. Buhmann B, Rainwater L, Schmaus G, Smeeding TM. Equivalence scales, well-being, inequality, and poverty: sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) data base. *Review of Income and Wealth* 1988;2:115-42.

21. Wolf PA, RB DA, Belanger AJ, Kannel WB. Probability of stroke: a risk profile from the Framingham Study. *Stroke* 1991;22:312-8.

22. Clauss A. Gerinnungsphysiologische Schnellmethode zur Bestimmung des Fibrinogens. *Acta Haematol* 1957;17:231-7.

23. Klipstein-Grobusch K, den Breeijen JH, Goldbohm RA, Geleijnse JM, Hofman A, Grobbee DE, Witteman JMC. Dietary assessment in the elderly: validation of a semiquantitative food frequency questionnaire. *Eur J Clin Nutr* 1998;52:588-96.

24. Herzog AR, Rodgers WL. Age and response rates to interview sample surveys. *J Gerontol* 1988;43:S200-5.

25. Kelsey JL, O'Brien LA, Grisso JA, Hoffman S. Issues in carrying out epidemiologic research in the elderly. *Am J Epidemiol* 1989;130:857-66.

26. Dronkers J, Ultee WC, ed. *Verschuivende ongelijkheid in Nederland. Sociale gelaagdheid en mobiliteit [in Dutch].* Assen: Van Gorcum, 1995:335.

27. van der Meer JB, Mackenbach JP. Low education, high GP consultation rates: the effect of psychosocial factors. *J Psychosom Res* 1998;44:587-97.

28. Stronks K. *Socio-economic inequalities in health: individual choice or social circumstances?* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1997.

29. Kaplan GA. Where do shared pathways lead? Some reflections on a research agenda. *Psychosom Med* 1995;57:208-12.

30. Salonen JT. Socioeconomic status and risk of cancer, cerebral stroke, and death due to coronary heart disease and any disease: a longitudinal study in eastern Finland. *J Epidemiol Community Health* 1982;36:294-7.

31. Howard G, Anderson R, Johnson NJ, Sorlie P, Russell G, Howard VJ. Evaluation of social status as a contributing factor to the stroke belt region of the United States. *Stroke* 1997;28:936-40.

32. Kawachi I, Marshall S, Pearce N. Social class inequalities in the decline of coronary heart disease among New Zealand men, 1975-1977 to 1985-1987. *Int J Epidemiol* 1991;20:393-8.

33. Jefferys M. Social inequalities in health-do they diminish with age? *Am J Public Health* 1996;86:474-5.

34. Fox AJ, Goldblatt PO, Jones DR. Social class mortality differentials: artefact, selection or life circumstances? *J Epidemiol Community Health* 1985;39:1-8.

35. Townsend P, Davidson N, Whitehead M, ed. *Inequalities in health (The Black Report & The health Divide).* London: Penguin Books, 1988.

36. Hoeymans N, Smit HA, Verkleij H, Kromhout D. Cardiovascular risk factors in relation to educational level in 36 000 men and women in The Netherlands. *Eur Heart J* 1996;17:518-25.

4.3 Socioeconomic status and myocardial infarction and cardiac mortality among Dutch elderly men. The Rotterdam Study

4.3.1 Introduction

Persons with a lower socioeconomic status have a higher risk for cardiovascular morbidity and mortality.[1] Evidence for this relationship has been predominantly obtained from studies among men younger than 65. Because the number of cardiovascular deaths as well as the prevalence of cardiovascular morbidity increases in older age groups, and because an increasing proportion of the population is growing older, it would be informative to study this relationship among the older population.

We determined the association between income and a first myocardial infarction and those with a history of myocardial infarction among elderly people. We also made a distinction between the fatal and non-fatal first myocardial infarctions. Additionally, in order to examine whether differences in morbidity reflect a higher cardiac mortality e.g. an increased case-fatality, we examined the association between income and cardiac mortality in a large cohort of Dutch elderly people.

4.3.2 Subjects, methods and results

The Rotterdam Study is a prospective population-based study of the occurrence and the determinants of chronic diseases among 7,983 men and women (response rate of 78%) aged 55 and over who live in one defined district of Rotterdam.[2] At the time of this analysis, follow-up data were available from the baseline period (1990-1993) until April 1st 1996, for 2,779 men, covering an average period of 4.0 (SD 0.8) years.

Income could not be assessed for men that lived in a home for the elderly (n=132) and information about income was missing for 275 men. Equivalent household income was defined as the household income at baseline adjusted for the number of persons living on that income. Participants' general practitioners and the municipal registry provided the research centre information on vital status and myocardial infarctions on a regular basis. Research physicians classified these events using additional information that was obtained from general practitioners' patients' records, interviews with relevant general practitioner and from hospital discharge records in cases of admittance or referral.

Total cardiac mortality was defined as deaths due to acute coronary disease (e.g. fatal myocardial infarction, sudden cardiac death (= death occurring instantaneously within one hour after the onset of the disease's symptoms which resulted in death or, in case of unwitnessed deaths, where cardiac deaths could not be excluded). or death due to heart failure. A myocardial infarction was based on a self-reported history of myocardial infarction with hospital admission, a first myocardial infarction or a sudden cardiac death. A myocardial infarction was classified as fatal when subjects died within 28 days after the infarction. Age-adjusted logistic regression and Cox' regression analyses were applied.

Table 4.3.1 Age-adjusted association between income and cardiac mortality, prevalent or incident myocardial infarction and fatal myocardial infarction.

	Incident first myocardial infarction or sudden cardiac death									Prevalent or incident myocardial infarction‡			Cardiac mortality		
	Fatal			Non-fatal			Total								
	N/n	RR†	95%-CI	N/n	RR†	95%-CI	N/n	RR†	95%-CI	N/n	OR	95%-CI	N/n	RR	95%-CI
- 4th quartile (high)	7/575	1		19/587	1		26/594	1		101/669	1		12/669	1	
- 3rd quartile	14/691	1.3	0.5-3.2	29/706	1.1	0.6-2.0	43/720	1.2	0.7-1.9	132/809	0.9	0.7-1.3	33/809	1.8	0.9-3.6
- 2nd quartile	9/420	1.2	0.4-3.2	18/429	1.1	0.6-2.1	27/438	1.1	0.6-1.9	98/509	1.1	0.8-1.5	30/509	2.2	1.1-4.3
- 1st quartile (low)	13/308	1.9	0.7-4.9	12/307	0.9	0.4-2.0	25/320	1.2	0.7-2.2	92/387	1.4	1.1-1.9	34/387	2.6	1.3-5.1

OR Odds ratio.

RR Relative risk.

CI Confidence interval.

N/n Number of events/total number in this group.

* Persons with a history of myocardial infarction have been excluded.

† Persons with no myocardial infarction were used as the reference group.

‡ A history of myocardial infarction or an incident first myocardial infarction or sudden cardiac death

At baseline, the subjects' mean age was 68 years (SD 8) and 302 subjects had a history of myocardial infarction. Furthermore, among those without a history of myocardial infarction, 121 people had a first myocardial infarction or died suddenly (fatal for 43 out of 121 subjects). During the follow-up period, 109 people died from cardiac causes, of which heart failure and myocardial infarction were the main causes.

Incidence of non-fatal myocardial infarction was not related to income, but fatal myocardial infarction occurred more often in the lower income groups (not statistically significant). The prevalence of those with a history of or a first myocardial infarction tended to be higher in the lower income groups. The risk of cardiac mortality for the lowest income quartile was two and a half times that of the highest income group. Not all cardiac deaths were due to a first fatal myocardial infarction. Another main cause of the cardiac deaths was heart failure, which was more common in the lower income groups (RR 12.6 1.6-97). Finally, about one third of the cardiac deaths occurred among those with a history of myocardial infarction. The relative risk for a cardiac death for the lowest versus the highest income groups was 6.7 (0.8-55).

4.3.3 Comments

People from lower socioeconomic groups who live on into old age may represent a relatively healthy subgroup; less viable individuals probably die at an earlier age. Therefore, it has been suggested that at older ages incidence and prevalence of myocardial infarction show weaker associations with socioeconomic status. However, our findings show that the survival probability after a myocardial infarction in the short and long run, and death due to heart failure at older ages differed by socioeconomic status. This is consistent with findings among younger age groups.[3,4] Explanations can be sought in socioeconomic differences in health care access, for example, delayed use of health services or lifestyle factors such as smoking or diet, which influence the severity of the disease.

In conclusion, income affects the chance of surviving a myocardial infarction. Studies on the prevention of fatal myocardial infarctions among lower socioeconomic groups are required in order to reduce the inequalities in health and to improve the health of a society in general.

4.3.4 References

1. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.

2. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

3. Lang T, Ducimetiere P, Arveiler D, Amouyel P, Cambou JP, Ruidavets JB, Montaye M, Meyer V, Bingham A. Incidence, case fatality, risk factors of acute coronary heart disease and occupational categories in men aged 30-59 in France. *Int J Epidemiol* 1997;26:47-57.

4. Morrison C, Woodward M, Leslie W, Tunstall-Pedoe H. Effect of socioeconomic group on incidence of, management of, and survival after myocardial infarction and coronary death: analysis of community coronary event register. *BMJ* 1997;314:541-6.

5
Socioeconomic status and cardiovascular risk factors

5.1 Socioeconomic status and nutrient intake. The Rotterdam Study

5.1.1 Abstract

Objective. Unfavourable dietary habits might explain a part of the increased cardiovascular morbidity and mortality among the lower socioeconomic groups. The aim of the study was to describe differences in dietary intake in older subjects by socioeconomic status, as indicated by educational level.

Design. A cross-sectional analysis of socioeconomic status in relation to dietary intake.
Setting. The Rotterdam Study.
Subjects. 2,213 men and 3,193 women, aged 55 years and over living in a district of Rotterdam, The Netherlands.

Results. In general, the dietary differences between socioeconomic groups were small. Lower educated subjects had a higher intake of almost all macronutrients compared with higher educated subjects. Furthermore, fat composition was more adverse in the lower educated strata; in lower educated subjects, relatively more energy was derived from saturated fat, the P:S ratio was lower and the intake of cholesterol higher. These differences could be explained by a higher intake of visible fat and more meat consumption. In addition, the composition of these products differed: the higher educated used relatively more lean meat and low-fat milk products. Furthermore, the intake of fibres was lower among the lower educated. Among lower educated groups there were more abstainers and the type of alcoholic beverages also differed between the groups. Intake of antioxidants from food alone did not differ between educational groups.

Conclusions. In Dutch elderly people, there are socioeconomic differences in dietary intake. Although these differences are small, these findings support the role of diet in the explanation of socioeconomic inequalities in cardiovascular health.

5.1.2 Introduction

Socioeconomic status has been shown to be inversely related to cardiovascular morbidity and mortality in several countries, including The Netherlands.[1,2] To detect high risk groups and target preventive care, more knowledge about the relationship between socioeconomic status and chronic disease is needed, particularly for the increasing elderly population, because data on socioeconomic inequalities among elderly people are scarce. One explanation for variation in disease with socioeconomic status is variation in the prevalence of cardiovascular risk factors.[1,3,4] In several studies an unfavourable cardiovascular risk profile, such as increased smoking or being overweight, has been reported to be more common in the lower socioeconomic strata, however, not all studies reported a universal unfavourable risk profile among the lower socioeconomic strata, for example the gradient with serum cholesterol is sometimes also observed in the opposite direction.[5] Dietary habits may explain another part of the increased morbidity and mortality among the lower socioeconomic groups.[6-11] Several physiological, social, and psychological factors have been proposed which contribute to nutritional problems in elderly people.[12] These are for example, lack of physical activity, declining absorption and metabolic capacities, drug-nutrition interactions, declining physical activity, increasing social solitude, shopping difficulties, and poor dentition. It is conceivable that at least some of these problems are more common in the lower socioeconomic strata.

We examined the differences in nutrient intake in older non-institutionalised men and women by education, an indicator of socioeconomic status. In addition, differences in food consumption were studied as well.

5.1.3 Subjects and methods

Study population

The present study was carried out as part of the Rotterdam Study, a prospective cohort study among 7,983 persons who live in one defined geographic area in Rotterdam, The Netherlands. The rationale and design of the study have been described elsewhere.[13] In summary, the objective of the Rotterdam Study was to investigate determinants of chronic and disabling cardiovascular, neurogeriatric, locomotor, and ophthalmologic diseases. All inhabitants aged 55 years and over of the district Ommoord in Rotterdam, were invited to participate. The baseline examinations started in 1990 and continued until June 1993. The examinations comprised a home visit by trained interviewers and two follow-up visits for a clinical examination at the research centre. Of the eligible subjects, 78% (7,983) was interviewed at home, and 7,006 out of 7,983 persons visited the research centre twice. The dietary interviews were not held with residents of homes for the elderly (n=479) nor with subjects with a reduced cognitive function as measured with a neuro psychological test (n=122). In addition, participants in the pilot phase of the study (n=277) did not receive a dietary questionnaire. A further 482 persons were excluded for logistic reasons (e.g. no dietician available). For 213 persons, the dieticians judged the reported dietary intake to be unreliable. This judgement was given directly after the interview by the same dietician who did the interview. Another 27 persons were excluded because data on educational level were missing. Eventually the analyses were based on 5,406 independently housed persons. The study was approved by the Medical Ethics Committee of Erasmus University. Written informed consent was obtained from all participants.

Measurements

Education Information on educational level was obtained by trained interviewers during the home visit. The participants were asked about their formal education, the number of years of each type of education and whether education had been completed. From this information the highest attained level of education was defined. This classification is similar to the UNESCO classification[14] and contains four categories: primary education; lower/intermediate general and lower vocational education; higher general and intermediate vocational education; higher vocational education and university.

Nutrient intake and dietary habits Dietary data were assessed with a semiquantitative food frequency questionnaire, containing 170 food items in 13 food groups. This questionnaire is a modified version of a previously validated questionnaire[15] and aims to estimate the habitual food intake during the last year. First, the questionnaire was left with the participants with careful instructions from the home interviewers. The subjects were asked to indicate which food items they used on a regular basis (at least twice a month). During the second visit to the research centre, frequencies and estimates of intake of selected foods were specified during a 20-minute interview with a trained dietician. Additionally, consistency checks of the completed dietary questionnaire were held and questions were asked about dietary habits, the use of food supplements and medically prescribed diets. The average daily intake of all food items and food groups was estimated for each person. Foods were converted to energy and nutrient intake with a computerised version of the Dutch Food Composition Table.[16] Intake of vitamin and mineral supplements was not included in the calculations of nutrient intake since brand labels of these supplements had not been recorded with sufficient accuracy.

Data analysis

Age-adjusted (eight 5-year age groups) and gender-specific mean intake of nutrients and foods according to educational groups was calculated on the basis of analysis of covariance. Discrete variables were analysed by means of age-adjusted and gender-specific logistic regression models. Statistical tests for trend were carried out with models in which education was included as an ordinal variable (1, 2, 3 or 4). In addition, an interaction term of age with educational level was included in the model to examine whether the socioeconomic differences in dietary intake were the same for the youngest versus the oldest participants. Furthermore, the mean intake of macronutrients according to educational groups (primary school; lower/intermediate general and lower vocational education; higher education) and age groups (younger than 65; 65-74; 75 years and above) was calculated on the basis of analysis of covariance. For all analyses a P-value less than 0.05 was considered statistically significant. All analyses were performed using the BMDP-package.[17]

Table 5.1.1 Age and educational level of the study population.

	Men	Women
Age in %	*n=2,213*	*n=3,193*
55 - 59 years	17	15
60 - 64 years	21	17
65 - 69 years	21	16
70 - 74 years	17	16
5 - 79 years	13	13
80 - 84 years	7	11
85 - 89 years	4	8
90 years and older	1	5
Education in %	*n=2,213*	*n=3,193*
Primary education	24.1	42.3
Intermediate general and lower vocational education	24.1	31.7
Higher general and intermediate vocational education	37.1	21.7
Higher vocational education and university	14.7	4.3

5.1.4 Results

General characteristics Distributions of age and educational level of the study population are shown in Table 5.1.1. The mean age for women was slightly higher than for men, 68 (SD 7) and 67 (SD 8) years respectively. A considerable part of the population (37%) had only attended primary school. Generally, men were higher educated than women. For example, 15% of the men and 4% of the women were classified in the highest educational groups. Educational level was inversely associated with age. Of subjects younger than 65, 12% was classified in the highest educational group versus 6% of subjects older than 65.

Nutrient intake Table 5.1.2 represents the intake of nutrients according to educational level. In general, the differences among women were similar to those among men, but they were slightly less pronounced. Persons with the lowest educational level reported the highest intake of energy. This was due to a higher absolute intake of protein, fat and carbohydrate in the lower strata. To avoid possible distortion caused by these different energy intakes, macronutrient intake was also calculated as a proportion of energy. The

Table 5.1.2 Mean daily intake of nutrients according to education and gender, adjusted for age (adjusted means (SE)).*

	Education 1		Education 2		Education 3		Education 4		Total		*P*-
Nutrient	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SD	trend
Men	*n=534*		*n=533*		*n=820*		*n=326*		*n=2,213*		
Total energy in MJ	9.60	0.09	9.44	0.09	9.41	0.07	8.94	0.11	9.40	2.12	<0.001
Total protein in g	89.5	0.9	88.6	0.9	88.9	0.7	86.0	1.2	88.5	20.7	0.057
Total protein in en%†	15.8	0.1	15.9	0.1	16.0	0.1	16.3	0.2	16.0	2.8	0.006
- Vegetable protein in en%	5.51	0.05	5.71	0.05	5.59	0.04	5.72	0.06	5.62	1.15	0.076
Total fat in g	94.6	1.2	92.6	1.2	92.4	1.0	86.0	1.6	92.0	28.6	<0.001
Total fat in en%	36.8	0.3	36.6	0.3	36.6	0.2	36.0	0.3	36.5	6.0	0.082
- Saturated fatty acids in en%	14.5	0.1	14.3	0.1	14.2	0.1	13.8	0.2	14.2	3.0	0.005
- Mono-unsaturated fatty acids in en%	12.8	0.1	12.4	0.1	12.5	0.1	12.2	0.2	12.5	2.8	0.014
- Poly-unsaturated fatty acids in en%	6.9	0.1	7.2	0.1	7.2	0.1	7.2	0.2	7.1	2.8	0.13
- P:S ratio	0.50	0.01	0.54	0.01	0.53	0.01	0.55	0.01	0.53	0.25	0.007
- Cholesterol in mg	271	4	258	4	259	3	240	5	259	89	<0.001
- Linoleic acid in g	14.3	0.4	15.3	0.4	15.1	0.3	14.5	0.5	14.9	8.1	0.47
Total carbohydrate in g	240.7	2.9	242.2	2.8	234.5	2.3	227.7	3.7	236.8	65.9	0.002
Total carbohydrate in en%	42.0	0.3	43.0	0.3	41.8	0.3	42.5	0.4	42.2	7.0	0.86
- Mono/disaccharides in en%	20.6	0.3	20.9	0.3	20.3	0.2	21.1	0.4	20.6	6.3	0.82
- Polysaccharides in en%	21.2	0.2	22.0	0.2	21.3	0.2	21.3	0.2	21.4	4.4	0.64
Fibre in g/MJ	1.88	0.02	1.94	0.02	1.94	0.02	2.03	0.03	1.94	0.52	<0.001

Nutrient	Education 1		Education 2		Education 3		Education 4		Total		P-trend
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SD	
Alcohol in en%	5.6	0.3	4.5	0.3	5.6	0.2	5.1	0.3	5.2	5.8	0.529
Potassium in g	3.96	0.04	3.92	0.04	3.89	0.03	3.84	0.05	3.91	0.86	0.039
Calcium in mg	1148	19	1164	19	1146	15	1129	24	1149	437	0.48
Sodium in g	2.46	0.03	2.50	0.03	2.48	0.02	2.34	0.04	2.46	0.72	0.056
Vitamin C in mg	114	2	115	2	114	2	120	3	115	50	0.18
β-carotene in mg	1.56	0.03	1.52	0.03	1.56	0.02	1.55	0.04	1.55	0.64	0.99
Vitamin E in mg	14.9	0.3	15.5	0.3	15.5	0.2	15.3	0.2	15.3	6.7	0.28
Women	*n=1,351*		*n=1,011*		*n=694*		*n=137*		*n=,3193*		
Total energy in MJ	7.54	0.05	7.47	0.05	7.40	0.06	7.17	0.14	7.47	1.69	0.008
Total protein in g	76.7	0.5	76.1	0.5	76.2	0.6	74.9	1.4	76.3	17.0	0.29
Total protein in en%	17.3	0.1	17.3	0.1	17.6	0.1	17.8	0.3	17.4	3.1	0.019
- Vegetable protein in en%	5.81	0.03	5.85	0.04	5.87	0.05	6.01	0.10	5.84	1.21	0.071
Total fat in g	74.3	0.6	72.7	0.7	70.7	0.9	67.8	2.0	72.3	23.4	<0.001
Total fat in en%	36.7	0.2	36.3	0.2	35.6	0.2	35.0	0.5	36.2	6.3	<0.001
- Saturated fatty acids in en%	14.6	0.1	14.6	0.1	14.2	0.1	13.8	0.3	14.5	3.3	<0.001
- Mono-unsaturated fatty acids in en%	12.4	0.1	12.3	0.1	12.0	0.1	12.0	0.2	12.3	2.7	<0.001
- Poly-unsaturated fatty acids in en%	6.8	0.1	6.6	0.1	6.7	0.1	6.4	0.2	6.7	2.8	0.097
- P:S ratio	0.49	0.01	0.48	0.01	0.50	0.01	0.50	0.02	0.49	0.24	0.60
- Cholesterol in mg	220	2	218	2	213	3	204	6	217	72	0.004

	Education 1		Education 2		Education 3		Education 4		Total		P-
Nutrient	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SD	trend
- Linoleic acid in g	11.4	0.2	10.9	0.2	11.0	0.2	10.5	0.6	11.1	6.5	0.073
Total carbohydrate in g	197.2	1.4	196.0	1.7	193.6	2.0	188.4	4.5	195.7	65.9	0.039
Total carbohydrate in en%	43.8	0.2	44.0	0.2	43.8	0.3	44.2	0.6	43.9	6.7	0.80
- Mono/disaccharides in en%	22.2	0.2	22.4	0.2	22.4	0.2	22.5	0.5	22.3	6.1	0.33
- Polysaccharides in en%	21.6	0.1	21.4	0.1	21.3	0.2	21.7	0.4	21.5	4.1	0.40
Fibre in g/MJ	2.17	0.02	2.19	0.02	2.21	0.03	2.29	0.05	2.19	0.61	0.022
Alcohol in en%	2.1	0.1	2.4	0.1	2.9	0.1	2.9	0.3	2.4	4.0	<0.001
Potassium in g	3.5	0.2	3.5	0.2	3.5	0.3	3.3	0.7	3.5	0.8	0.020
Calcium in mg	1114	10	1099	12	1124	14	1093	93	1111	377	0.98
Sodium in g	2.05	0.02	2.00	0.02	2.03	0.03	1.99	0.05	2.03	0.57	0.17
Vitamin C in mg	126	2	124	2	122	2	120	5	124	56	0.14
β-carotene in mg	1.49	0.02	1.51	0.03	1.56	0.03	1.56	0.07	1.51	0.82	0.07
Vitamin E in mg	12.9	0.2	12.7	0.2	12.6	0.2	12.3	0.5	12.8	5.6	0.19

* 1= Primary school;
2= Lower general and vocational education;
3= Intermediate/higher general and intermediate vocational education;
4= Higher vocational education / university.

† In percentages of total energy.

SE Standard error.

SD Standard deviation.

protein intake as a proportion of energy was lower among the lower educated. Among women in the lowest strata more energy was derived from fat. The composition of fat differed across the educational groups in that the contribution of saturated fat was higher and for men the P:S ratio was lower in the lower strata. Also, the intake of dietary cholesterol was higher in the lower educated groups. The intake of carbohydrate in energy percentages did not differ between the educational groups. The intake of fibre in g/MJ was on average lower in the lowest educational groups. This was due to higher energy intake instead of a lower absolute intake of fibre (results not shown). Energy intake derived from alcohol was lower in the lower socioeconomic groups, especially for women. The intake of sodium was underestimated, as discretionary salt intake was not included. The intake of potassium from the food products was inversely related to education for men and women. Vitamin intake by food groups did not differ significantly. Furthermore, higher educated persons took more vitamin and mineral supplements (data not shown).

To test whether the educational differences change with age, we included an interaction term of educational level with age in the model. For men, the educational differences in nutrient intake lessens with increasing age (Table 5.1.3); interaction terms of age and education were statistically significant. Generally, energy and macro nutrient intake fell with age; the exception was alcohol intake in the lowest educated groups. These decreases were more pronounced in the lowest educated groups. The changes in macronutrients as proportions of energy were less clear. For women, the decline with age was less pronounced as for men. Also, the interaction terms were not statistically significant and age-stratified analyses did not show substantial age-related changes in the educational differences.

Food consumption To explain the absolute differences in nutrient intake we calculated the intakes of foods according to educational group (Table 5.1.4). Lower socioeconomic groups reported a higher intake of products that are high in protein, like meat and cheese (the latter only for men). As meat, visible fat (e.g. butter, margarine, and oils), cheese and milk products are the main sources of fat, differences in intake of these products may explain the differences in fat intake. The lower educated consumed significantly more meat and, among men, also less fish. In addition, lower educated women used relatively more high fat meat instead of lean meat. The contribution to the total meat consumption of lean versus higher fat meat products was similar across male educational groups (results not shown). For women, the total absolute amount of visible fat was higher in the lower educational groups, but the composition was not significantly different between the socioeconomic groups (results not shown). For men, the total intake of visible fat was not different, while the proportion of poly-unsaturated fatty acids was lower and the proportion of mono-unsaturated fatty acids was higher among the lowest educated

Table 5.1.3 Mean daily intake of macronutrients according to education, age and gender.

	Men					Women				
	Age below 65		Age above 75		*P*-inter-action*	Age below 65		Age above 75		*P*-inter-action
	Lowest educated	Highest educated	Lowest educated	Highest educated		Lowest educated	Highest educated	Lowest educated	Highest educated	
	n=181	*n=546*	*n=138*	*n=153*		*n=431*	*n=417*	*n=395*	*n=127*	
Total energy in MJ	10.07	9.47	9.03	9.03	0.003	7.63	7.38	7.45	7.37	0.61
Total protein in g	96.7	92.6	81.5	84.8	0.003	78.7	78.1	74.0	74.3	0.75
Total protein in en%	16.4	16.4	15.3	15.9	0.37	17.6	18.0	16.8	17.3	0.81
Total fat in g	99.4	92.6	88.6	88.2	0.02	74.5	69.4	75.2	72.2	0.70
Total fat in en%	36.7	36.1	36.6	36.4	0.29	36.4	35.0	37.6	36.3	0.89
- Saturated fatty acids in en%	14.5	13.9	14.8	14.2	0.066	14.3	13.6	15.5	14.8	0.34
Total carbohydrate in g	254.2	236.2	229.8	235.6	0.002	198.7	191.2	195.8	194.8	0.69
Total carbohydrate in en%	42.2	41.7	42.9	43.7	0.011	43.6	43.4	44.1	44.3	0.89
Alcohol in g	15.6	18.4	16.4	11.8	0.003	6.3	8.8	3.3	4.8	0.89
Alcohol in en%	2.4	3.5	1.3	2.0	0.005	2.4	3.5	1.3	2.0	0.80

* Based on the whole population.

Table 5.1.4 Mean daily intake of some food groups according to education, adjusted for age and gender (adjusted means (SE)).*

	Education 1		Education 2		Education 3		Education 4		Total		P-
Nutrient	mean	SE	mean	SE	mean	SE	mean	SE	mean	SD	Trend
Men	*n=534*		*n=533*		*n=820*		*n=326*		*n=2,213*		
Potatoes in g	171	3	155	3	154	3	141	4	157	77	<0.001
Vegetables in g	226	4	216	4	223	3	212	5	221	92	0.13
Fruit in g	196	6	208	6	202	5	228	7	206	131	0.008
Meat in g	130	2	121	2	126	2	116	3	124	51	0.005
Fish in g	16	1	16	1	17	1	19	1	17	19	0.048
Milk products in g	383	12	404	12	398	10	401	16	396	282	0.41
Cheese in g	41	1	40	1	39	1	36	1	39	26	0.016
Eggs in number/week	2.04	0.05	2.00	0.05	1.97	0.04	1.83	0.07	1.97	1.24	0.029
Visible fat in g	46	1	47	1	46	1	44	1	46	20	0.14
Bread in g	153	3	164	3	157	2	149	3	156	60	0.31
Nuts, savoury snacks in g	20	1	20	1	20	1	18	1	59	46	0.79
Pastries, biscuits, sweets in g	39	1	41	1	40	1	34	2	39	34	0.14
Women	*n=1,351*		*n=1,011*		*n=694*		*n=137*		*n=3,193*		
Potatoes in g	116	2	111	2	101	2	85	5	110	57	<0.001
Vegetables in g	220	3	219	4	220	5	203	10	219	123	0.43
Fruit in g	239	4	246	4	245	5	259	11	243	131	0.11
Meat in g	100	2	99	2	94	2	86	4	98	43	<0.001

	Education 1		Education 2		Education 3		Education 4		Total		*P*-
Nutrient	mean	SE	mean	SE	mean	SE	mean	SE	mean	SD	Trend
Fish in g	15	0	15	1	15	1	19	2	15	18	0.11
Milk products in g	403	7	390	8	405	9	391	21	399	245	0.81
Cheese in g	34	1	34	1	34	1	36	2	34	21	0.28
Eggs in number/week	1.72	0.03	1.74	0.04	1.79	0.04	1.86	0.10	1.75	1.12	0.08
Visible fat in g	37	0	36	1	36	1	34	1	37	17	0.04
Bread in g	123	1	120	1	118	2	117	4	120	44	0.009
Nuts, savoury snacks in g	16	1	17	1	20	1	19	2	17	25	0.007
Pastries, biscuits, sweets in g	40	1	41	1	39	1	37	1	40	33	0.40

* 1= Primary school;

2= Lower general and vocational education;

3= Intermediate/higher general and intermediate vocational education;

4= Higher vocational education / university.

SE Standard error.

SD Standard deviation.

Table 5.1.5 Mean daily intake of beverages according to education, adjusted for age and gender (adjusted means (SE) and percentages).*

	Education 1		Education 2		Education 3		Education 4		Total		*P*-trend
Nutrient	mean/%	SE	mean/%	SE	mean/%	SE	mean/%	SE	mean/%	SD	trend
Men	*n=534*		*n=533*		*n=820*		*n=326*		*n=2,213*		
Tea in ml	295	10	321	10	317	8	347	13	317	242	<0.001
Coffee in ml	537	11	536	11	505	9	481	14	516	259	<0.001
Use of alcohol in %	84.5		85.4		90.6		90.3		87.8		<0.001
Of alcohol users:	*n=447*		*n=451*		*n=740*		*n=294*		*n=1,932*		
- Beer in ml	161	12	109	12	107	9	88	15	117	260	<0.001
- Wine in ml	11	3	15	3	23	2	25	3	19	54	<0.001
- Medium strong alcoholic drinks in ml	12	2	9	2	10	2	10	34	6	40	0.99
- Strong alcoholic drinks in ml	46	3	38	3	46	2	43	60	10	34	0.40
Women	*n=1,351*		*n=1,011*		*n=694*		*n=137*		*n=3,193*		
Tea in ml	384	7	410	8	413	10	469	22	402	259	0.006
Coffee in ml	466	6	450	7	439	8	395	18	452	216	<0.001
Use of alcohol in %	68.5		75.5		76.9		82.0		73.1		<0.001
Of alcohol users:	*n=914*		*n=775*		*n=547*		*n=113*		*n=2,349*		
- Beer in ml	7	1	5	1	4	2	9	4	6	40	0.46
- Wine in ml	22	2	21	2	25	2	26	5	23	50	0.14
- Medium strong alcoholic drinks in ml	20	2	22	2	29	2	29	5	23	48	0.001
- Strong alcoholic drinks in ml	9	1	9	1	10	1	6	3	9	28	0.86

* 1= Primary school; 2= Lower general and vocational education; 3= Intermediate/higher general and intermediate vocational education; 4= Higher vocational education / university

SE Standard error

SD Standard deviation

(results not shown). Milk consumption did not differ but the lower educated consumed relatively less skimmed milk products and more semi-skimmed and fresh milk products (results not shown). The higher cholesterol intake in the lower strata may be explained by a higher intake of products that are high in cholesterol such as meat, visible fat, milk (products) and cheese. The higher intake of carbohydrate among the lower educated persons was mainly due to a higher intake of bread (women) and potatoes. This does not imply a higher fibre intake among the lower educated, as they consumed relatively less wholemeal bread (results not shown). Furthermore, less fruit was consumed in the lower strata (Table 5.1.4). In addition, the lower educated subjects drank less tea and more coffee. Use of alcohol was positively related with education (Table 5.1.5). Finally, among alcohol consumers, the type of drink varied between educational groups. Lower educated male alcohol consumers drink less wine and more beer, while higher educated women, drink more wine and more medium strong alcoholic drinks.

5.1.5 Discussion

The main findings of the present study are that nutrient intake and dietary habits vary according to education among Dutch elderly people, although these differences are small. Lower educated persons report a higher intake of almost all macronutrients, especially dietary fat, compared with higher educated persons. Also the composition of fat is unfavourable with the lower educated; relatively more energy is derived from saturated fat. The intake of cholesterol is higher for both sexes and for men the P:S ratio is lower in the lower educated groups. Differences in dietary fat intake can be explained by a higher intake of visible fat and more meat consumption. In addition, the composition of food products differs: the higher educated use relatively more lean meat or skimmed milk products. Moreover, the intake of fibres per MJ is lower among the lower educated. Among the lower educated groups there are more alcohol abstainers and the type of alcoholic beverages differed between the groups; the lower educated drank less wine (both sexes), less medium to strong alcoholic drinks (women), and more beer (men).

To appreciate the findings, certain aspects of the study should be considered. First, the potential of selective participation needs to be addressed. In our study population, the non-response rates were 15% and 37% for subjects younger than 65 and for those aged 75 and over respectively. Therefore, it is likely that the study population represents a relatively healthy cohort as older persons and those with health problems are less able to participate[18,19]. Besides, persons with impaired cognitive function were excluded and also the exclusion of persons with unreliable data might be related to their cognitive function. As cognitive decline and morbidity are associated with socioeconomic status and poor nutritional habits,[20,21] we suspect that the differences that emerged are underestimations of the real differences. As it is not likely that exclusion criteria other than cognitive function (for instance, logistic reasons) were related to educational level, they will therefore not have introduced a bias.

We used a semiquantitative food frequency questionnaire to assess the dietary intake. This method is attractive because the data are relatively simple to collect and represent intake over an extended period, which is the usual frame of interest for chronic diseases. This questionnaire is a modified version of a previously validated questionnaire with a good validity and reproducibility.[15,22] This modification concerns a different mode of administration (not with just a self-administered questionnaire) and an addition of slightly more food items that are commonly consumed by elderly people. The validity of our method was assessed with a subsample of 80 men and women aged 55 to 75. The nutrient intake estimated from the food frequency questionnaire was compared with estimated nutrient intake over a total of 15 days of food records collected over a one-year period. In short, the food frequency questionnaire was able to rank subjects adequately according to their dietary intake.[23]

So as to measure socioeconomic status in this study, we used the indicator 'education' because education represents the aspect of knowledge and attitude, while income and occupation emphasise other aspects of socioeconomic level. Lifestyle factors such as diet are expected to be greatly influenced by knowledge.[24] In addition, other aspects of socioeconomic status also influence dietary habits and many areas overlap among the main indicators of socioeconomic status. This is confirmed by our findings (not shown) that other available indicators of socioeconomic status, e.g. income and occupational level, in general showed the same trends, although these were less pronounced.

Compared with Dutch guidelines the mean intake of energy (except for the highest educated), protein, total fat (except for the highest educated women) and saturated fatty acids is too high, and the average intakes of carbohydrate and fibre as observed in our study too low. The intake of vitamins appears to be adequate. However, the value of these guidelines, especially for the very advanced old people may be limited, as they are based on much younger persons. So far, few data are available on optimal nutrient intake in elderly people. Some issues may be of particular importance in the 'oldest old' people such as, for example, interaction of nutrient intake with medication intake, or loss of vitamins by cooking warm meals for more days. In general the dietary intake of the higher socioeconomic groups tends to be closer to the current dietary recommendations.

Previous studies in younger persons on socioeconomic differences in dietary habits also showed a lower socioeconomic status to be associated with worse dietary habits, although this association is somewhat more pronounced than in our study among elderly persons in which the absolute differences were small.[6-9,25-27] This may be due to our study population and to the fact that survivors into old age in lower socioeconomic strata represent a relatively healthier group. In addition, these stronger findings among younger persons confirm our findings among men of a decline in the differences with age.

In contrast to other studies, we hardly found differences in the intake of micronutrients and antioxidants (from food alone) between educational groups.[10,25] Possible explanations for this contrast might be our study population or the Dutch food pattern. For instance, the homogeneity in vitamin C in our study population can be explained by the traditional Dutch food pattern that contains relatively high potato consumption. Although the higher educated groups consumed more fruit, the lower educated consumed more potatoes which contributes also a considerable part of the total vitamin C intake.

Explanations for the socioeconomic differences in nutrient and energy intake can be several. First, the dietary requirements may be different due to for example activity patterns, body size or basal metabolism. As the dietary requirements at younger ages are determined among other things by someone's occupation, it is logical that among men the educational differences in macronutrients decline with age. At younger ages, the difference in requirements between higher and lower educated men will be much larger compared to the differences in requirements when they are retired. However, these factors probably explain only a small part of the differences in intake of energy, since our study and several previous studies have shown that obesity is inversely related to socioeconomic status (results not shown). These different requirements would, however, not explain differences in macronutrient intake as a proportion of energy. Secondly, it is likely that the socioeconomic groups have different attitudes towards foods, healthy foods, nutritional quality of conventional foods, and use of nutritional supplements.[28] Reasons for these different attitudes may reflect a limited knowledge about a healthy diet. This is confirmed by the findings that in higher educated groups the use of lean products, wholemeal products, and supplements is more common. This is assumed to be a result of a greater awareness of the benefits of eating healthy products.[29] Attitudes towards food may be affected by a different culture within some socioeconomic classes or family, and could cluster with other lifestyle factors. In other studies, differences have been reported between the diet of smokers and non-smokers.[30] Furthermore, the price of food products and the budget available to buy food might also play a role in the dietary habits. Differences in income could explain differences in intake of certain food groups. For example, lean meat is generally more expensive than high-fat meat. Finally, morbidity, especially among the advanced old, might explain socioeconomic differences in dietary intake. Morbidity may lead to less physical activity, or loss of appetite, which might lower the intake of energy and nutrients.

Our data show that modest socioeconomic differences in diet exist among Dutch elderly people. The biological significance of each of these observed differences by education would be limited. Despite, at population level, the effect of a modest change in a risk factor may result in a significant health change in the population. In our population, in particular this effect may be more substantial as a large proportion of people is classified in the lower educated category. In addition, as dietary habits affect several biological mechanisms the cumulative effect of a more unhealthy diet among the lower educated would not be negligible.

We conclude that there were small socioeconomic differences in dietary intake among Dutch elderly people. Nutrition-related risk factors for cardiovascular disease were more common among the lower educated as they have a diet which contains e.g. more fat, has a less favourable fat composition, contains more cholesterol and fewer fibre and less persons use alcohol. This suggests that differences in diet could play a modest role in explaining socioeconomic inequalities in cardiovascular health in elderly people. Longitudinal studies are required to assess the extent to which differences in nutrient intake result in differences in cardiovascular morbidity and mortality.

5.1.6 References

1. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.

2. Mackenbach JP. Socio-economic health differences in The Netherlands: a review of recent empirical findings. *Soc Sci Med* 1992;34:213-26.

3. Fox AJ, Goldblatt PO, Jones DR. Social class mortality differentials: artefact, selection or life circumstances? *J Epidemiol Community Health* 1985;39:1-8.

4. Townsend P, Davidson N, Whitehead M, ed. *Inequalities in health (The Black Report* & *The health Divide).* London: Penguin Books, 1988.

5. Marmot MG, Rose G, Shipley M, Hamilton PJ. Employment grade and coronary heart disease in British civil servants. *J Epidemiol Community Health* 1978;32:244-9.

6. Bolton-Smith C, Smith WC, Woodward M, Tunstall-Pedoe H. Nutrient intakes of different social-class groups: results from the Scottish Heart Health Study (SHHS). *Br J Nutr* 1991;65:321-35.

7. Hulshof KF, Löwik MR, Kok FJ, Wedel M, Brants HA, Hermus RJ, ten Hoor F. Diet and other life-style factors in high and low socio-economic groups (Dutch Nutrition Surveillance System). *Eur J Clin Nutr* 1991;45:441-50.

8. Popkin BM, Siega-Riz AM, Haines PS. A comparison of dietary trends among racial and socioeconomic groups in the United States. *N Engl J Med* 1996;335:716-20.

9. Shimakawa T, Sorlie P, Carpenter MA, Dennis B, Tell GS, Watson R, Williams OD. Dietary intake patterns and sociodemographic factors in the atherosclerosis risk in communities study. ARIC Study Investigators. *Prev Med* 1994;23:769-80.

10. Davey Smith G, Brunner E. Socio-economic differentials in health: the role of nutrition. *Proc Nutr Soc* 1997;56:75-90.

11. James WP, Nelson M, Ralph A, Leather S. Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. *BMJ* 1998;316:308-9.

12. Horwath CC. Dietary intake studies in elderly people. *Wld Rev Nutr Diet* 1989;59:1-70.

13. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

14. Unesco. *International Standard Classification of Education (ISCED)*. Paris, 1976.

15. Goldbohm RA, van den Brandt PA, Brants HA, van't Veer P, Al M, Sturmans F, Hermus RJ. Validation of a dietary questionnaire used in a large-scale prospective cohort study on diet and cancer. *Eur J Clin Nutr* 1994;48:253-65.

16. NEVO-tabel. *Dutch Food Composition Table 1993 [in Dutch]*. The Hague: Voorlichtingsbureau voor de Voeding, 1993.

17. Dixon WJ, ed. *BMDP Statistical Software Manual*. Berkeley: University of California Press, 1990.

18. Herzog AR, Rodgers WL. Age and response rates to interview sample surveys. *J Gerontol* 1988;43:S200-5.

19. Kelsey JL, O'Brien LA, Grisso JA, Hoffman S. Issues in carrying out epidemiologic research in the elderly. *Am J Epidemiol* 1989;130:857-66.

20. Fox AJ. Socio-economic differences in mortality and morbidity. *Scand J Soc Med* 1990;18:1-8.

21. Marmot MG, Kogevinas M, Elston MA. Social/economic status and disease. *Annu Rev Public Health* 1987;8:111-35.

22. Willet WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Withi J, Hennekens CH, Speizer FE. Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol* 1985;122:51-65.

23. Klipstein-Grobusch K, den Breeijen JH, Goldbohm RA, Geleijnse JM, Hofman A, Grobbee DE, Witteman JMC. Dietary assessment in the elderly: validation of a semiquantitative food frequency questionnaire. *Eur J Clin Nutr* 1998;52:588-96.

24. Liberatos P, Link BG, Kelsey JL. The measurement of social class in epidemiology. *Epidemiol Rev* 1988;10:87-121.

25. Hulshof KF, Wedel M, Löwik MR, Kok FJ, Kistemaker C, Hermus RJ, ten-Hoor F, Ockhuizen T. Clustering of dietary variables and other lifestyle factors (Dutch Nutritional Surveillance System). *J Epidemiol Community Health* 1992;46:417-24.

26. Löwik MR, Westenbrink S, Wedel M, Schrijver J. Invloed van sociaal-economische factoren op voeding en voedingstoestand van ouderen [in Dutch]. *Voeding* 1989;50:38-42.

27. Morgan M, Heller RF, Swerdlow A. Changes in diet and coronary heart disease mortality among social classes in Great Britain. *J Epidemiol Community Health* 1989;43:162-7.

28. Horwath CC. Socio-economic and behavioral effects on the dietary habits of elderly people. *Int J Biosocial Med Research* 1989;11:15-30.

29. McIntosh WA, Kubena KS, Walker J, Smith D, Landmann WA. The relationship between beliefs about nutrition and dietary practices of the elderly. *J Am Diet Assoc* 1990;90:671-6.

30. Fehily AM, Phillips KM, Yarnell JW. Diet, smoking, social class, and body mass index in the Caerphilly Heart Disease Study. *Am J Clin Nutr* 1984;40:827-33.

5.2 Sociodemographic factors and prevalence, treatment, and control of hypertension. The Rotterdam Study

5.2.1 Abstract

Objective. To assess the prevalence, level of treatment and control of hypertension in a general elderly population, by age and sociodemographic factors.

Design. A cross-sectional analysis.

Setting. The Rotterdam Study.

Participants. 7,983 subjects, aged 55 years and over living in a district of Rotterdam.

Main outcome measure. Prevalence of hypertension based on blood pressure levels (160/95 mmHg) and use of blood pressure lowering medication for the indication of hypertension, type of treatment and control of hypertension.

Results. Systolic blood pressure rises with age while diastolic blood pressure levels off. The prevalence of hypertension increases with age and was higher among women than among men. The overall prevalence of hypertension was 39% in women and 31% in men. About 80% of the hypertensives was aware of having hypertension from which 82% was treated. For 70% of those, treatment was adequate with reference to conservative criteria. Hypertension was more prevalent among persons not living in an elderly home, higher educated men and lower educated women. Persons without a partner and men living in an elderly home had a higher risk of being unaware or not being treated for their hypertension. Treatment was more often successful among those living in an elderly home.

Conclusions. The prevalence of hypertension is higher among older women and increases with age in both sexes. A large part of hypertensive elderly people is aware and is treated for hypertension. Nevertheless, the majority of hypertensives does not have their hypertension well controlled. This group needs more attention in medical practice in order to reduce the burden of cardiovascular disease in elderly people.

5.2.2 Introduction

Hypertension is an important risk factor for cardiovascular disease. One of the cornerstones of primary prevention of cardiovascular disease has been screening for high blood pressure and anti-hypertensive drug treatment.[1] Until recently, elderly subjects were excluded from treatment studies, despite the fact that they are at high risk for morbidity or death from hypertension-related diseases.[2] Currently however, the benefits of anti-hypertensive drug therapy for older persons have been clearly established.[3-8] Results from trials and meta-analyses have shown that anti-hypertensive drug treatment for older hypertensive persons confers highly significant and clinically relevant reductions in cardiovascular morbidity and mortality.[2,8] Still, a considerable percentage of older people with hypertension are not detected or not adequately treated for hypertension. In the USA, however, an improvement in the level of awareness, treatment and control among elderly people has been reported during the last decades, although this improvement appeared to decline in the most recent period.[9] Epidemiological studies on hypertension diagnosis and control among elderly people in Europe are limited.[10] Furthermore, the question arises which factors determine the awareness and treatment status of hypertension. Several studies have reported an inverse association between socioeconomic status and prevalence of hypertension or level of blood pressure.[11] Besides socioeconomic status, it is likely that other sociodemographic factors affect also the prevalence of hypertension. In addition, these sociodemographic factors might determine the level of awareness and quality of treatment and control of hypertension. Therefore, we provide data on prevalence, treatment, awareness and control of hypertension among an elderly Dutch population. In addition, we examined whether there are socioeconomic and demographic differences in hypertension diagnosis and treatment.

5.2.3 Subjects and methods

Study population

The present study was conducted as a part of the Rotterdam Study, a prospective cohort study among 7,983 persons (response rate = 78%) aged 55 years and over and living in one defined geographic area in Rotterdam, The Netherlands. The rationale and design of the study have been described elsewhere.[12] In summary, the objective of the Rotterdam Study is to investigate determinants of chronic and disabling cardiovascular, neurogeriatric, locomotor, and ophthalmologic diseases. The baseline examination started in 1990 and continued until June 1993. The examinations comprised a home visit by trained interviewers and two follow-up visits for a clinical examination at the research centre. The study was approved by the Medical Ethics Committee of Erasmus University and written informed consent was obtained from all participants.

Measurements

Blood pressure. Systolic and diastolic blood pressure were measured at one occasion, on the right upper arm, twice in sitting position with a random-zero-sphygmomanometer. The mean of the two blood pressure readings was used to determine blood pressure levels. Hypertension was defined as a systolic blood pressure of 160 mmHg or over, and/or a diastolic blood pressure of 95 mmHg or over, and/or current use of blood pressure lowering drugs for the indication of hypertension. The use of medication and type of medication were assessed during the home interview by a research assistant. The participants subsequently showed all their currently used medication at the research centre where a physician determined for what indication this medication had been prescribed. In case of blood pressure levels below the cut-off points and inconsistencies or missing values on indication, additional information was used to classify subjects into hypertensives or non-hypertensives. This additional information was obtained first from the response to the question 'Have you ever been told by a doctor that you have hypertension?' and second from the response to the question 'Were you ever treated with drugs because of high blood pressure.'

Hypertensives were classified into four subgroups; 'treated and controlled', 'treated and uncontrolled', 'untreated and aware ' and 'untreated and unaware', based on their awareness, treatment status and control of hypertension. In those hypertensives who were treated, a distinction was made between those for whom blood pressure was below 160/95 mmHg and thus controlled ('treated and controlled'), and those for whom blood pressure was not controlled ('treated and uncontrolled'). Information on awareness was obtained on the basis of the question 'Have you ever been told by a doctor that you have hypertension?' By definition, those who where treated were considered to be aware of having hypertension. Blood pressure lowering drugs could be classified into three categories, e.g. 'diuretics', 'β-blockers' and 'other anti-hypertensive medication'.

Sociodemographic factors. Information on education, occupation and income as indicators of socioeconomic status was obtained by trained interviewers during the home visit, at baseline of the study (1990-1993). Similar results were observed for the associations of hypertension with these different indicators. We report in this paper the results for the indicator 'education' only, as the number of missing values (4%) for this indicator was the lowest. The participants were asked about their formal education, the number of years of each type of education and whether education had been completed. From this information the highest attained level of education was defined and this was classified into three categories: low (primary education); medium (lower general education and lower vocational education); high (higher general education, intermediate vocational education, higher vocational education and university). The other sociodemographic factors, i.e. 'having a partner', health insurance and living situation, were assessed during the same interview on basis of a questionnaire. Based on the question about partnership subjects were categorised into two groups: currently having a partner; and those without a partner including widowed and divorced persons. Health insurance was dichotomised into health insurance via sickness fund (for persons below a certain income level) and private insurance (for persons above this income level and civil servants). Living situation was divided into living independently and living in a house for the elderly.

Data analysis

All analyses were performed with the SPSS-package and for women and men separately. The prevalence of hypertension was assessed on the basis of 5-year age bands. These age-specific prevalences were weighted according to the age distribution in The Netherlands in groups. Mean blood pressure levels according to 10-year age bands and by subgroups of hypertensives were calculated using regression analysis. In addition, regression analyses in which age was included as an ordinal variable (1,2, 3 and 4) were done to test for trend.

Multivariate linear and logistic regression analyses were performed to determine the age-adjusted association between several sociodemographic factors and the blood pressure levels, prevalence of hypertension, being unaware of having hypertension compared to being aware, being untreated compared to being treated and being uncontrolled compared to having controlled hypertension. In addition, the relationship between these factors and the use of a certain type of medication was assessed by multivariate logistic regression.

Table 5.2.1 *Characteristics of the study population.*

	Men	Women
Age in %	*n=3,105*	*n=4,878*
55 - 59 years	16.5	14.7
60 - 64 years	20.9	17.2
65 - 69 years	21.1	15.6
70 - 74 years	16.8	15.7
75 - 79 years	12.5	13.2
80 - 84 years	7.4	10.6
85 years and older	4.9	12.9
Education in %	*n=3,017*	*n=4,552*
High: Intermediate/higher general education, intermediate/higher vocational education and university	49.6	23.2
Medium: Lower general and lower vocational education	22.5	28.5
Low: Primary education	27.9	48.3
Having a partner in %	*n=2,662*	*n=4,375*
Having a partner	83.7	50.8
Having no partner (including widowed and divorced persons)	16.3	49.2
Living situation in %	*n=3,105*	*n=4,878*
Living independently	94.0	85.4
Living in a house for the elderly	6.0	14.6
Health insurance in %	*n=3,105*	*n=4,878*
Private insurance	51.9	36.8
Sickness Fund	48.1	63.5

5.2.4 Results

Distributions of age and sociodemographic variables of the study population are shown in Table 5.2.1. The mean age in women was slightly higher than in men; 72 (SD 9) and 69 (SD 10) years respectively. Forty percent of the population had only attended primary school. Generally, men had higher education levels than women; 15% of the men and 4% of the women were classified in the highest educational groups. Educational level was inversely associated with age. Of subjects younger than 65, 13% were classified in the highest educational group versus 6% of subjects older than 65. The majority, 84% of the men and 51% of the women had a partner and the proportion of widowed or divorced women was higher than the proportion of widowed or divorced men (results not shown). Furthermore, relatively more women were institutionalised compared to men. Finally, relatively more men than women had private insurance.

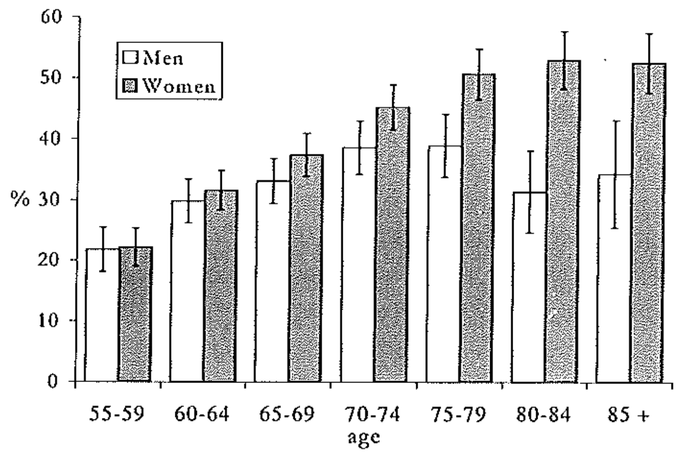


Figure 5.2.1
Prevalence of hypertension *
by age and sex.

* Hypertension was defined as a systolic blood pressure of 160 mmHg or over, a diastolic blood pressure of 95 mmHg or over or current use of blood pressure lowering drugs for the indication of hypertension.

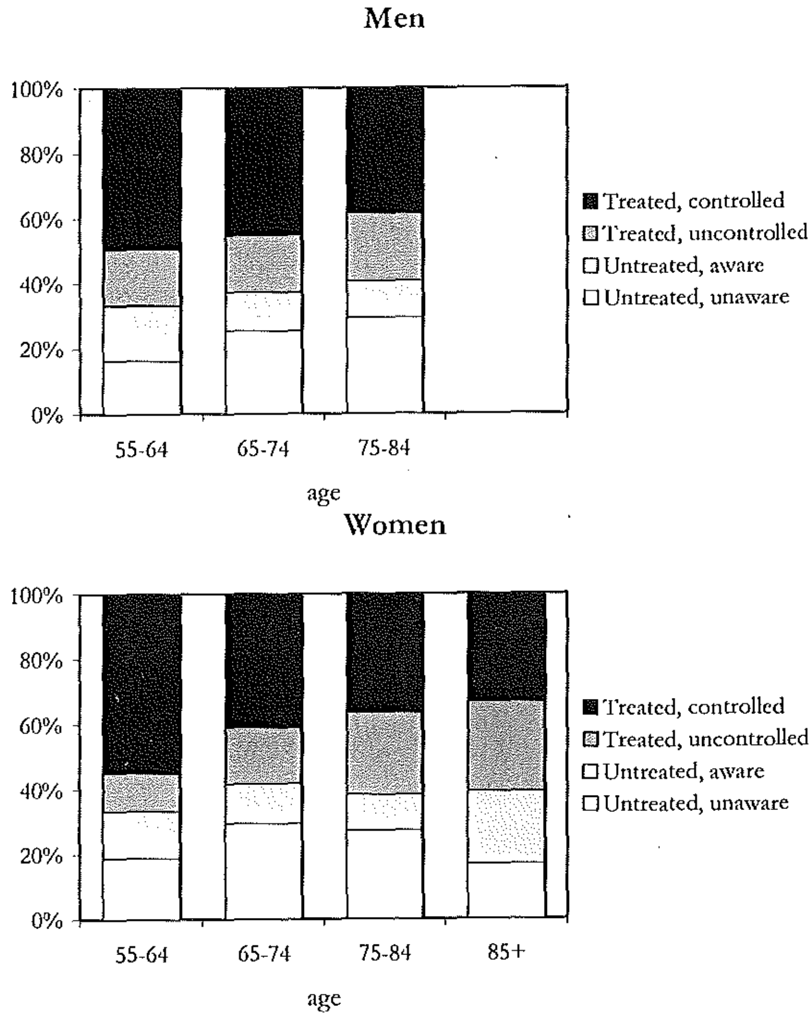
Prevalence of hypertension

Figure 5.2.1 shows the increasing prevalence of hypertension with age for men and women. The overall prevalence of hypertension, standardised to the total Dutch population, was higher in women than in men, 39% and 31% respectively. For women, the prevalence of hypertension continuously increased with age, from 22% in the youngest age group to 52% in those of 85 years and over. For men, the prevalence increased with age until 80 years from 22% to 39%.

Awareness, treatment and control of hypertension

Figure 5.2.2 shows the levels of awareness, treatment and control of hypertension for male and female hypertensives by age. In total, 25% of the hypertensive men and 18% of

*Figure 5.2.2 Distribution of hypertension across categories of unawareness, treatment and control by age and sex.**



* Due to missing values, the classification into awareness, treatment and control could not be made for 224 hypertensives.

the hypertensive women were not aware of having hypertension. Of those aware of hypertension about 82% were treated. Furthermore, 70% of those treated were normotensive under treatment. From all hypertensives, only 46% had controlled hypertension. For both sexes, this proportion of controlled hypertensives decreased with age, while the proportion of treated uncontrolled increased with age. For men, also, the proportion of persons aware of having hypertension (treated and untreated) decreased with age.

Table 5.2.2 Mean systolic and diastolic blood pressure in mmHg according to age and sex in the total population and across categories of awareness, treatment and control of hypertension.

	Total population			Normotensives		Participants with actual hypertension							
						Untreated, Unaware		Untreated, Aware		Treated, Uncontrolled		Treated, Controlled	
	N	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP
Men, aged 55+	2,797	138.7	74.5	130.8	71.4	171.1	84.5	170.8	89.6	175.6	87.0	135.8	74.4
- Aged 55-64	1,095	134.7	76.1	128.3	73.2	170.1	91.1	171.1	91.4	172.8	91.1	135.1	77.2
- Aged 65-74	1,074	140.4	74.5	132.5	71.1	170.9	86.2	169.8	88.5	175.6	86.3	135.6	74.2
- Aged 75-84	518	142.3	71.5	132.5	68.2	171.9	79.9	175.0	86.9	179.4	83.4	137.7	69.4
- Aged 85+	110	145.1	72.9	134.0	69.4	*	*	*	*	*	*	*	*
P-trend		<0.001	<0.001	<0.001	<0.001	0.50	<0.001	0.46	0.078	0.008	0.003	0.26	<0.001
Women, aged 55+	4,212	139.9	73.1	130.0	69.7	170.9	83.0	172.7	85.5	173.6	83.4	137.5	73.1
- Aged 55-64	1,470	130.8	73.5	124.4	70.8	168.6	86.8	168.4	88.0	167.8	89.3	134.4	76.3
- Aged 65-74	1,392	142.1	73.5	132.9	69.8	171.2	83.4	171.5	85.7	171.9	84.5	139.8	73.5
- Aged 75-84	953	147.8	72.7	135.8	68.3	172.4	79.8	175.5	85.2	176.6	82.2	138.6	70.5
- Aged 85+	396	147.2	71.1	134.9	66.4	170.3	83.7	177.6	81.0	175.6	77.1	135.2	66.3
P-trend		<0.001	<0.001	<0.001	<0.001	0.32	0.035	<0.001	0.006	<0.001	<0.001	0.053	<0.001

SBP Systolic blood pressure.

DBP Diastolic blood pressure.

* The number in this group is smaller than 25 and therefore no mean is given.

Blood pressure

Table 5.2.2 shows the mean systolic and diastolic blood pressure values for the total population and for subgroups defined by awareness and treatment status. In general, systolic blood pressure increased and the diastolic blood pressure decreased with age. Women showed a stronger increase in systolic blood pressure with age than men. The decrease in diastolic blood pressure with age is more marked among men than women. Despite these differences between men and women, mean systolic and diastolic blood pressure did not considerably differ between men and women. The mean systolic and diastolic blood pressures of controlled hypertensives was slightly higher than those of the normotensives.

Anti-hypertensive drug treatment

Table 5.2.3 shows the proportions of the various blood pressure lowering drugs used by men and women in mono-therapy or in combination therapy. Diuretics were more prescribed at older ages and to women. Furthermore, the use of β-blockers decreased with age. Other anti-hypertensive drugs, such as calcium antagonists, were mainly prescribed to male hypertensives aged 65-74 and women aged 75-84. The proportion using other anti-hypertensives drugs was higher in men compared to women.

Table 5.2.3 Use of the various anti-hypertensive agents, for men and women.

	N (=100%)	Diuretics (%)	β-blockers (%)	Other anti-hypertensive agents(%)
Male treated hypertensives	576	32.7*	51.5	52.5
- Aged 55-64	195	23.1	52.3	51.8
- Aged 65-74	251	30.8	52.0	57.2
- Aged 75-84	117	49.6	50.4	45.3
Male normotensives†	1,867	4.9	6.5	5.4
Female treated hypertensives	1,191	52.9	45.0	39.1
- Aged 55-64	291	42.1	52.1	32.1
- Aged 65-74	417	48.2	50.6	37.6
- Aged 75-84	362	61.3	39.0	45.0
- Aged 85 +	121	70.3	27.3	43.0
Female normotensives†	2,521	7.5	4.1	3.4

* Diuretics, β-blockers and other anti-hypertensive agents are prescribed in mono-therapy as well as in combination-therapy. Therefore, the sum of the proportion of users of diuretics, the proportion of users of β-blockers and the proportion of users of other anti-hypertensive agents exceeds 100%.

† Using these medications for indications other than hypertension.

Table 5.2.4 Sociodemographic factors and hypertension, being unaware of having hypertension, being untreated or uncontrolled (odds ratios adjusted for age).

	Total population		Hypertensives		Aware hypertensives		Treated hypertensives	
	Hypertension		Unaware*		Untreated†		Uncontrolled‡	
	OR	95%-CI	OR	95%-CI	OR	95%-CI	OR	95%-CI
Men								
Education								
- Medium (versus high)	0.90	0.73-1.10	1.29	0.86-1.92	0.74	0.42-1.39	1.22	0.76-1.95
- Low (versus high)	0.85	0.70-1.03	1.26	0.86-1.85	0.83	0.50-1.39	0.90	0.56-1.45
Having no partner (versus having a partner)	1.11	0.87-1.43	1.45	0.93-2.27	2.89	1.65-5.08	0.96	0.50-1.86
Health insurance via Sickness fund (versus Private insurance)	0.93	0.78-1.09	1.13	0.82-1.56	0.59	0.38-0.90	0.92	0.62-1.35
Living in house for the elderly (versus living independently)	0.84	0.57-1.22	1.49	0.78-2.85	2.51	0.96-6.57	0.36	0.13-1.55
Women								
Education								
- Medium (versus high)	1.17	0.98-1.40	1.01	0.68-1.50	0.90	0.59-1.37	0.87	0.58-1.31
- Low (versus high)	1.20	1.01-1.42	0.92	0.64-1.32	0.89	0.61-1.32	1.12	0.77-1.63
Having no partner (versus having a partner)	0.94	0.81-1.09	0.97	0.71-1.32	1.39	0.99-1.95	0.87	0.64-1.20
Health insurance via Sickness fund (versus Private insurance)	0.99	0.87-1.13	1.09	0.82-1.44	1.03	0.76-1.40	0.89	0.67-1.18
Living in house for the elderly (versus living independently)	0.53	0.42-0.67	1.07	0.68-1.68	1.05	0.58-1.89	0.40	0.24-0.66

* Risk for being 'Untreated unaware' for all hypertensives.

† Risk for being 'Untreated aware' for all aware hypertensives ('Treated controlled', 'treated uncontrolled' and 'untreated aware').

‡ Risk for being 'Treated uncontrolled' for all treated hypertensives.

OR Odds ratio.

CI Confidence interval.

It should be noted that blood pressure lowering drugs are also prescribed for indications other than hypertension, for the normotensives as well as hypertensives. For example, almost 13% of the normotensives were using blood pressure lowering drugs for an indication other than hypertension.

Differences by socioeconomic and demographic factors

Table 5.2.4 shows the age-adjusted odds ratios for hypertension, being unaware, untreated or uncontrolled according to several sociodemographic factors. Hypertension was slightly more frequent among the higher educated men, lower educated women and those not living in a house for the elderly. A higher systolic blood pressure was observed among those not living in a house for the elderly (for women and men, 12 mmHg and 6 mmHg, respectively).

Among male hypertensives, lower educated men, those living in a home for the elderly and those without a partner tended to be less aware of their hypertension. Among female hypertensives, no clear sociodemographic differences in awareness were observed.

For those aware of their hypertension, men and women without a partner, men with a private health insurance or men living in a house for the elderly were less often treated. Finally, from treated persons living independently, a lower proportion had controlled hypertension compared to those living in an home for elderly.

Type of treatment differed also by these sociodemographic factors. β-blockers were less prescribed to the lower educated persons, those with insurance via the sickness fund, men with a partner and women without a partner [results not shown]. Diuretics were less prescribed to the lower educated women and to women without a partner. Finally, other anti-hypertensive agents were more prescribed to women without a partner and those living in a house for the elderly [results not shown].

5.2.5 Discussion

This study provides data on prevalence, treatment, awareness and control of hypertension among an elderly Dutch population. Furthermore, data on sociodemographic differences in hypertension diagnosis and treatment and control of hypertension are given. To appreciate the findings, certain methodological aspects of the study should be considered.

First, the potential of selective participation needs to be addressed. In spite of a high response rate, it is likely that our study population is relatively healthy compared to the total Dutch population, because older persons and those with health problems are less likely to participate.[13,14] Consequently, the true prevalence of hypertension in the Dutch population of 55 years and older may be somewhat higher. In addition, our study population includes relatively more older persons than the total Dutch population in these age groups. This latter problem was solved by calculating total prevalence of hypertension on the basis of age-weighted prevalences.

Blood pressure was measured twice at one visit. This may lead to an overestimation of the prevalence of hypertension and to an underestimation of adequately controlled patients among those treated with anti-hypertensive medication.[15] For this reason, we used a definition of hypertension based on rather conservative blood pressure levels and the use of blood pressure lowering medication. The relatively high blood pressure criteria limit the potential of misclassification of a diagnosis of hypertension as blood pressure levels were based on measurements obtained at a single occasion. Comparison of the prevalence of hypertension with other studies should be done with caution due to different cut-off points, number of measurements or different measurement techniques.[16,17] For example, if we had chosen for lower cut-off points of blood pressure levels (140/90) in stead of 160/95 mmHg, the prevalence of hypertension would have been 52% and 58%, for men and women respectively. In our study, we did not include in the prevalence estimates persons with a normal blood pressure who are using blood pressure lowering drugs for other indications than hypertension. Results from this study indicate that blood pressure lowering drugs are frequently used also for other indications, especially in an older population. In several other reports users of blood pressure lowering drugs however, were not specified by indication.

The classification of hypertensives into 'untreated and unaware', 'untreated and aware' and 'treated and uncontrolled' may be affected by the differences in cognitive performance in this elderly population. Persons with cognitive decline could be misclassified, as they are likely to have had more problems with answering the questions. Furthermore, it is likely that cognitive decline with age is more prevalent among those with a lower socioeconomic status,[18]among older persons, and possibly even in those with clinically elevated blood pressure levels. The direction in which this misclassification has affected the results is unclear.

To classify socioeconomic status in this study, we used the indicator 'education'. Each indicator, e.g. education, occupation and income, represents another dimension of socioeconomic status. However, there is some overlap among the main indicators of socioeconomic status. This is confirmed by our findings (not shown) that other available indicators of socioeconomic status, e.g. income and occupational level, in general showed the same trends.

The results of this study demonstrate that hypertension is more prevalent among elderly women than among men, and that the prevalence increases with age. Although comparison with other studies is difficult due to problems mentioned above, our results do not substantially differ from a recent overview of studies on the prevalence of hypertension in The Netherlands.[16] Other studies among elderly subjects have similarly shown a higher prevalence of hypertension among women compared to men and an increase with age.[6,9,10,17,19] Hormonal factors and post menopausal weight gain and a different risk profile might explain the higher age-specific prevalence of hypertension among women compared to men.[9] Diastolic blood pressure levels off with age,[10,20] and at older ages systolic blood pressure rises, resulting in a higher prevalence of isolated systolic blood pressure.[9] Possibly, the decline in diastolic blood pressure reflects increased atherosclerosis in this ageing population due to stiffening of large arteries.[21]

Several studies have demonstrated a beneficial effect of treatment in older persons. Trials of patients older than 60 years have shown that anti-hypertensive drugs therapy reduces the risk of stroke, cardiovascular disease, heart failure and mortality.[3-7,22] Still, several studies including ours, have shown that a considerable proportion of the hypertensives are not aware of having hypertension and that among those who are aware a considerable proportion are not treated.[10,23-27] The frequencies of awareness, however, appear to vary substantially, ranging from 23% in China to 97% in the USA.[26] The percentage of aware hypertensives in our study population, about 75%, is lower than reported from most industrialised countries.[10] Similar to most other studies, the women in our population have a better awareness than men.[24,26] This finding suggests that general practitioners make different monitoring and treatment decisions according to sex, or that health consciousness differs between sexes.

In our male study population, unawareness of hypertension tended to increase with age. Several explanations for this increase with age can be considered. First, it is likely that physicians are still more hesitant to diagnose hypertension in elderly people, due to lack of consensus on the cut-off points for hypertension and a possible awareness of white coat hypertension among elderly people.[28] Second, it is possible that the physician-patient communication differs with age. Third, cognitive function of the participants may have affected the awareness.

About 66% of the hypertensives in our study population were treated, and for a majority of those (70%) this treatment was adequate with reference to our conservative criteria. Comparing this proportion with the 'rules of halves' which has been the dogma of the past (i.e., only half of the hypertensives are detected, half of which are treated, of which only half achieve adequate blood pressure control) and other recent surveys among elderly people,[20,29] suggests that there is an increasing tendency for medical treatment among elderly people and a better quality of control. However, still a considerable portion of the hypertensives are not treated or are treated ineffectively, especially at older ages. Indeed, in view of the recent data from the HOT (Hypertension Optimal Treatment) study, only 30% of the treated hypertensives in our study population reached the rather low targets defined in this trial. However, the public health impact of even a small decline can be substantial.

Till now, no single drug class is regarded uniquely suitable as the first choice therapy for al elderly patients. For example, Messerli reported a poor impact of β-blockers on the blood pressure levels and the prevention of cardiovascular disease exclusive of stroke, in older hypertensives.[30] Therefore, it is not possible to judge whether the persons are treated in an optimal way. The most appropriate choice of anti-hypertensive drug often depends on comparative adverse profiles, presence of co-morbidity[15] and use of other medication.[31] This might explain why treatment strategies differ according to sex and age. For example, diuretics were more often prescribed at older ages and to women and β-blockers were less prescribed at older ages. In addition, our study showed that these medications are also frequently given for other indications.

Several studies have reported an inverse association between socioeconomic status and hypertension or blood pressure level.[11,32] Our findings among women are consistent with these studies. The positive association observed among men, however, is in contrast to these studies and also in contrast to recent studies conducted in The Netherlands among younger persons.[33] Nonetheless, the results in men are in line with Dutch studies carried out some decades ago.[34,35] Hoeymans et al reported a change of the association between socioeconomic status and hypertension with time in The Netherlands.[33] Our findings suggest, however, that this change may not occur within a generation but rather across the generations.

Our finding that health insurance status affects treatment of male hypertensives suggests that either Dutch physicians distinguish between type of insurance or that men with private insurance use medical care in a different way compared with those without private insurance.

Especially among men, 'Having a partner' may have a beneficial effect on the awareness and treatment of hypertension.[36] Explanations for these associations with partnership need further investigation.

For the majority of the hypertensives, 54%, blood pressure levels were not controlled. In order to achieve a better control of hypertension among elderly people, more attention should be given to detect and subsequently treat and control hypertension. Subgroups that need special care are men without a partner and men living in an elderly home.

In conclusion, the prevalence of hypertension is higher among older women and increases with age for both sexes. A substantial proportion of hypertensive elderly people are aware and successfully treated for hypertension. However, still a considerable proportion, which increases with age, does not have their hypertension well controlled. These hypertensives need more attention in the medical practice in order to reduce the burden of cardiovascular disease in elderly people.

5.2.6 References

1. Whelton PK. Epidemiology of hypertension. *Lancet* 1994;344:101-6.

2. Reynolds E, Baron RB. Hypertension in women and the elderly. Some puzzling and some expected findings of treatment studies. *Postgrad Med* 1996;100:58-63, 67-70.

3. Ooi HH, Coleman PL, Duggan J, YM OM. Treatment of hypertension in the elderly. *Curr Opin Nephrol Hypertens* 1997;6:504-9.

4. Lindholm LH. Antihypertensive treatment in the elderly. *Clin Exp Hypertens* 1996;18:435-47.

5. Chalmers J. Hypertension in the elderly: benefits of treatment. *Blood Press* 1995;Suppl:6-10.

6. Hansson L. Hypertension in the elderly. *J Hypertens Suppl* 1996;14:S17-21.

7. Prince MJ. The treatment of hypertension in older people and its effect on cognitive function. *Biomed Pharmacother* 1997;51:208-12.

8. Staessen JA, Fagard R, Thijs L, Celis H, Arabidze GG, Birkenhager WH, Bulpitt CJ, de Leeuw PW, Dollery CT, Fletcher AE, Forette F, Leonetti G, Nachev C, ET OB, Rosenfeld J, Rodicio JL, Tuomilehto J, Zanchetti A. Randomised double-blind comparison of placebo and active treatment for older patients with isolated systolic hypertension. The Systolic Hypertension in Europe (Syst-Eur) Trial Investigators. *Lancet* 1997;350:757-64.

9. Anonymous. The sixth report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure. *Arch Intern Med* 1997;157:2413-46.

10. Trenkwalder P, Ruland D, Stender M, Gebhard J, Trenkwalder C, Lydtin H, Hense HW. Prevalence, awareness, treatment and control of hypertension in a population over the age of 65 years: results from the Starnberg Study on Epidemiology of Parkinsonism and Hypertension in the Elderly (STEPHY). *J Hypertens* 1994;12:709-16.

11. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88:1973-98.

12. Hofman A, Grobbee DE, de Jong PT, van den Ouweland FA. Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;7:403-22.

13. Herzog AR, Rodgers WL. Age and response rates to interview sample surveys. *J Gerontol* 1988;43:S200-5.

14. Kelsey JL, O'Brien LA, Grisso JA, Hoffman S. Issues in carrying out epidemiologic research in the elderly. *Am J Epidemiol* 1989;130:857-66.

15. Birkett NJ, Donner AP, Maynard MD. Assessing hypertension control in the community: the need for follow-up measurements to ensure clinical relevance. *CMAJ* 1987;136:595-600.

16. van de Mheen PJ, Bonneux L, Gunning-Schepers LJ. Variation in reported prevalences of hypertension in The Netherlands: the impact of methodological variables. *J Epidemiol Community Health* 1995;49:277-80.

17. Guibert R, Franco ED. Choosing a definition of hypertension: impact on epidemiological estimates. *J Hypertens* 1996;14:1275-80.

18. Zhu L, Viitanen M, Guo Z, Winblad B, Fratiglioni L. Blood pressure reduction, cardiovascular diseases, and cognitive decline in the mini-mental state examination in a

community population of normal very old people: a three-year follow-up. *J Clin Epidemiol* 1998;51:385-91.

19. Applegate WB. Hypertension in elderly patients. *Ann Intern Med* 1989;110:901-15.
20. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, Horan MJ, Labarthe D. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. *Hypertension* 1995;25:305-13.
21. Witteman JC, Grobbee DE, Valkenburg HA, van Hemert AM, Stijnen T, Burger H, Hofman A. J-shaped relation between change in diastolic blood pressure and progression of aortic atherosclerosis. *Lancet* 1994;343:504-7.
22. Schoenberger JA. Epidemiology and evaluation: steps toward hypertension treatment in the 1990s. *Am J Med* 1991;90:3S-7S.
23. De Henauw S, De Bacquer D, Fonteyne W, Stam M, Kornitzer M, De Backer G. Trends in the prevalence, detection, treatment and control of arterial hypertension in the Belgian adult population. *J Hypertens* 1998;16:277-84.
24. Marques-Vidal P, Arveiler D, Amouyel P, Bingham A, Ferrieres J. Sex differences in awareness and control of hypertension in France. *J Hypertens* 1997;15:1205-10.
25. Burt VL, Culter JA, Higgins M, Horan MJ, Labarthe D, Whelton P, Brown C, Roccella EJ. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population. Data from the health examination surveys, 1960 to 1991. *Hypertension* 1995;26:60-9.
26. Marques-Vidal P, Tuomilehto J. Hypertension awareness, treatment and control in the community: is the 'rule of halves' still valid? *J. Hum. Hypertens.* 1997;11:213-20.
27. Klungel OH, de Boer A, Paes AH, C. SJ, Nagelkerke NJ, Bakker A. Undertreatment of hypertension in a population-based study in The Netherlands. *J Hypertens* 1998;16:1371-8.
28. Wiinberg N, Hoegholm A, Christensen HR, Bang LE, Mikkelsen KL, Nielsen PE, Svendsen TL, Kampmann JP, Madsen NH, Bentzon MW. 24-h ambulatory blood pressure in 352 normal Danish subjects, related to age and gender. *Am J Hypertens* 1995;8:978-86.
29. Stieber J, A. D, U. K. Frequency, level of knowledge and level of treatment of hypertension in a city population. Results of the First Munich Blood Pressure Study [in German]. *Munch Med Wochenschr* 1982;124:747-52.
30. Messerli FH, Grossman E, Goldbourt U. Are beta-blockers efficacious as first-line therapy for hypertension in the elderly? A systematic review. *JAMA* 1998;279:1903-7.
31. Schwartz JB. Calcium antagonists in the elderly. A risk-benefit analysis. *Drugs Aging* 1996;9:24-36.
32. Tyroler HA. Socioeconomic status in the epidemiology and treatment of hypertension. *Hypertension* 1989;13:I94-7.

33. Hoeymans N, Smit HA, Verkleij H, Kromhout D. Cardiovascular risk factors in relation to educational level in 36 000 men and women in The Netherlands. *Eur Heart J* 1996;17:518-25.

34. Duijkers TJ, Kromhout D, Spruit IP, Doornbos G. Inter-mediating risk factors in the relation between socioeconomic status and 25-year mortality (the Zutphen Study). *Int J Epidemiol* 1989;18:658-62.

35. Appels A, Otten F, Mendes de Leon C, Sturmans F, Mulder P, Schuurman J. De KRIS follow-up studie VII. Sociaal-economische status en gezondheid [in Dutch]. *Soc Geneesk* 1990;68:298-305.

36. Gutzwiller F. Health education and public health policies for detection, prevention, and treatment of hypertension. *J Clin Hypertens* 1986;2:210-5.

6
General Discussion

6.1 Introduction

'By the year 2000 the differences in health status between countries and between groups within countries should be reduced by at least 25% by improving the level of health of disadvantaged nations and groups'.[1] Since the World Health Organisation initiated this target, there have been many studies on socioeconomic inequalities among countries and among groups. Most of these studies have shown that people in low socioeconomic groups are worse off with respect to their health.

Despite the evident need to study socioeconomic differences among elderly people, this age-group has so far received little attention in the scientific literature. The aim of this thesis was to gain insight into socioeconomic inequalities among Dutch elderly people, thereby focussing on cardiovascular disease and all cause mortality. This chapter recapitulates the main findings with regard to socioeconomic inequalities among the Dutch elderly population, the limitations of these analyses and recommendations for policy measures and future research.

6.2 Main findings

An overview of the findings as reported in the previous chapters is provided in Table 6.1. Besides the reported associations, the Rotterdam Study also allows for research into many other associations of socioeconomic status with cardiovascular disease or risk factors to be carried out. For a more comprehensive overview of socioeconomic inequalities in this study population, a summary of these associations has been added to the table. The associations shown in this table are based on absolute differences, relative risks or odds ratios of the lowest socioeconomic groups versus the highest socioeconomic groups.

6.2.1 Socioeconomic status of elderly people

On average, men had a higher socioeconomic status than women. Furthermore, an older person was more likely to have a lower socioeconomic status. The associations between socioeconomic status and health differed across the indicators of socioeconomic status ('income', 'education' and 'occupation'). However, on the basis of the studies in this

Table 6.1 Overview of the studied socioeconomic differences in cardiovascular risk factors, diseases and mortality in the Rotterdam Study

	Study population	Chapter	Men			Women			
							Occupation		
			Education	Occupation	Income	Education	Own	Head of household	Income
Mortality, total	A	3.1	–	–	–	–	.	.	.
Cardiovascular disease	B	N	.	.	–	.	.	.	.
- Cardiac deaths	B	4.3/N	.	.	–	.	.	.	.
Neoplasms	B	N	(–)	.	.	(–)	.	.	(–)
Other	B	N	.	.	.	–	.	.	.
Cardiovascular disease									
Any aortic calcification	C	4.1	.	.	.	–	–	.	.
Severe aortic calcification	C	4.1	.	.	.	.	–	.	–
Prevalence of self-reported myocardial infarction	B	N	(–)	.	.	.	.	–	.
Incidence of myocardial infarction or sudden cardiac death	D	4.3/N	.	.	.	.	.	.	.
Fatal myocardial infarction	D	4.3/N	.	.	.	.	.	.	.
Prevalence of self-reported stroke	B	4.2/N	.	.	.	(–)	–	.	–
Incidence of stroke	D	4.2/N	.	.	.	(–)	.	–	(–)
Prevalence of self-reported cardiovascular disease‡	B	4.2/N	–	.	–	(–)	–	–	–
Risk factors									
Systolic blood pressure	E	4.2/N*	(+)	+	(+)	.	–	.	.
Hypertension	E	4.2/5.2/N	(+)	(+)	+	–†	–	.	.
Cigarette smokers	E	4.2/N	–	–	–	–	.	–	–
Non-smokers	E	4.2/N	+	+	.	.	(–)	.	.
Number of smoking years	A	N	–	–	–	–	.	(–)	–
'Unhealthy' diet	A	5.1/N	–	–	–	–	–	–	–
Use of alcohol	E	4.2/N	+	+	+	+	+	+	+
High alcohol consumption	A	N	.	.	+	.	.	.	.
Total serum cholesterol	A	N	–	.	–	.	.	–	.
Total HDL	A	N	.	.	.	+	(+)	+	+
Fibrinogen	E	4.2/N	.	.	.	–	(–)	.	.
Atrial fibrillation	E	4.2/N	.	(–)	.	.	.	.	.
Left ventricular hypertrophy	A	N	+	.	.	.	.	.	.
Body mass index	A	N	–	.	.	–	–	–	–
Waist-hip ratio	A	N	–	–	–	.	.	.	.
Diabetes mellitus (using medication or insulin)	E	4.2/N	.	.	.	.	.	–	–

+ = Statistically significant ($P<0.05$) positive association: the higher the socioeconomic status the higher the risk, prevalence or value.
– = Statistically significant negative association. ( ) = borderline statistically significant association ($P<0.10$).
. = No statistically significant association.
N Results were not reported in previous chapters.
† In Chapter 5.2 this association was not statistically significant due to a smaller number of participants.
‡ Myocardial infarction, coronary artery bypass surgery, angina pectoris, intermittent claudication or percutaneous transluminal angioplasty.
A Whole study population (n=7,983).
B Whole study population for whom complete follow-up data on cardiovascular disease are available (n=7,053).
C Whole study population after examination phase 2.
D Whole study population for whom follow-up data are available, excluding prevalent cases.
E All associations for men, and the association of own occupation for women are based on study population B. The other associations for women are based on study population A (as reported in Chapter 4.2).

thesis, it is not possible to conclude which socioeconomic indicator has the best overall discriminating power.

6.2.2 Socioeconomic inequalities in mortality

In the Rotterdam Study the risk of mortality in the lowest socioeconomic groups was approximately 1.5-2 times higher compared to that in the highest socioeconomic groups. For women, only the association with education was statistically significant, whereas for men the inverse association was observed for all three indicators of socioeconomic status. The higher mortality rate among lower educated women was caused by neoplasms and other non-cardiovascular and non-cancerous causes. More men in the lower socioeconomic groups however, died from a cardiac death or from neoplasms compared to the higher socioeconomic groups.

Analyses among British civil servants in the first Whitehall Study have shown clear inverse associations between employment grade and almost all causes of death. Compared to the Rotterdam Study, the associations for British civil servants were stronger. The association decreased with increasing age, but was still present in the group of 70 years and over. Furthermore, no significant differences were observed in the seasonal fluctuations of mortality between the lowest and highest employment grades.

6.2.3 Socioeconomic inequalities in cardiovascular disease

The associations between socioeconomic status and several cardiovascular disease outcomes were not consistent for men and women. Aortic atherosclerosis, as indicated by calcified plaques on radiographic films was more common in lower socioeconomic strata of women. Again for women, a strong association with stroke was observed: elderly women in the lowest socioeconomic groups had a higher risk of suffering from stroke compared to those in the higher socioeconomic groups. For men, no socioeconomic differences were found in the presence of aortic atherosclerosis or stroke. Self-reported cardiovascular disease was inversely related to socioeconomic status both for men and women. Furthermore, socioeconomic status hardly affects the incidence and prevalence of myocardial infarction, but there was a weak association between socioeconomic status and probability of survival after a myocardial infarction, although this association was not statistically significant.

6.2.4 Socioeconomic inequalities in cardiovascular risk factors

Among women, clear associations were not found for all risk factors for cardiovascular diseases, but the findings pointed consistently into the same direction: the lower socioeconomic groups had a worser risk profile for cardiovascular disease. The lower socioeconomic groups comprised more hypertensives, smokers and diabetics. Furthermore, those in lower socioeconomic groups had a more 'atherogenic' diet, higher total cholesterol and lower high-density lipoprotein levels, and a higher body mass index.

In general though, these main risk factors could only explain a small part of the association between socioeconomic status and a number of outcome measures, for example stroke and aortic calcification.

Among men, socioeconomic differences in cardiovascular risk factors were less consistent: high blood pressure levels and hypertension, extreme alcohol use and left ventricular hypertrophy were more common in the higher socioeconomic groups, whereas smoking habits, dietary habits and the distribution of body fat mass were more unfavourable in the lower socioeconomic groups.

Thus, we found socioeconomic differences in mortality and some cardiovascular diseases. However, we did not find socioeconomic differences for all the diseases and risk factors. Except for stroke, socioeconomic differences in diseases and risk factors were not big. However, since the majority of the population is classified in lower socioeconomic groups, it means that at the population level the impact of socioeconomic status on health cannot be neglected. Among women, all associations pointed into the same direction, namely the risk profile is worser for elderly women in the lower socioeconomic groups, they suffer more often from diseases and have a shorter life expectancy. Risk factors could only explain a small proportion of the associations. This picture was less clear for men.

6.3 Limitations and strengths of this study

Before we can draw conclusions from these findings, the limitations and strengths of the study will be considered. As some of these have already been discussed in the previous chapters, this section provides a more general discussion of methodological issues. First, the study population is discussed: the effect of non-response and sample size. Subsequently, the measurement of socioeconomic status, as well as risk factors and health will be considered. Furthermore, attention is paid to the method of analysis by discussing refinements on the conceptual model for the association between socioeconomic status and health. Finally, the generalisability of our findings is discussed.

6.3.1 Non-response

Despite the high response rate in our study, the distribution of socioeconomic status may be biased by non-response. It can be argued that, in relatively terms, the groups of non-respondents had a lower socioeconomic status. While such a selection could have influenced descriptive data as described in Chapter 2, it will have hardly affected the strength of associations between socioeconomic status and health or risk factors as described in the other chapters. Still, it is conceivable that the more susceptible persons have dropped out. In this case, the association of socioeconomic status with health and risk factors might have been stronger in those that have dropped out (because of illness or death) than in those that participated in our study. We expect that, if anything, such selection has led to an underestimation of the socioeconomic differences in health.

Furthermore, the associations could theoretically be biased due to missing values for the indicators of socioeconomic status. However, this effect may well be only minor because the number of missing values was small. For example, for the indicator 'education' the number of missing values was 3%. This effect may be greater for income, because 11% of the participants that live independently had a missing value on this variable. In addition, the indicator 'income' was not assessed for all institutionalised participants. Differences in health according to income are therefore based on a relatively healthy population compared to differences in health according to the other socioeconomic indicators. Such selection will have probably led to an underestimation of the true differences.

6.3.2 Sample size and length of follow-up

Although the optimal sample size of a study is commonly larger than one that is actually used, one of the strengths of the Rotterdam Study nonetheless is its large sample size. It would be unreasonable to assume that a sample of almost 8,000 elderly people is too small for a study of socioeconomic differences at a cross-sectional level. Yet, for the longitudinal analyses of our study population, the length of the follow-up period may have been too short to detect any statistically significant associations. However, during the 4 years of follow-up about 1,300 deaths, 300 myocardial infarctions and 300 strokes occurred. Still, a longer follow-up period would increase the number of occurrences and change the confidence intervals, although it would probably not change the point estimates.

6.3.3 Measurement of socioeconomic status

Measuring socioeconomic status in older persons has its limitations, as mentioned in detail in Chapter 3.1.2. Briefly, measurement of socioeconomic status is complicated due to retirement, changing family structure, institutionalising, or cognitive decline. In addition, the socioeconomic impact of a certain educational level or occupation may have changed over the last decades, partly due to increasing numbers in higher socioeconomic groups.

Although not all problems are solved, a strength of this study was that we were able to assess extensively all three main indicators of socioeconomic status by which socioeconomic levels can be classified. Although associations with risk factors or health outcomes were not found for all socioeconomic indicators, in most cases the observed associations for the different indicators pointed in the same direction.

6.3.4 Measurement of risk factors and health outcomes

Another strength of this study is that we were able to assess the association of many indicators of socioeconomic status with many determinants and health outcomes. Furthermore the determinants of diseases and health outcomes are assessed using mainly 'objective' measurements. This is in contrast to studies in which self-reported health and self-reported determinants were used. Most associations in our study are therefore not biased as a result of different perceptions of health across the various socioeconomic groups.

6.3.5 Appropriate model?

Studies on socioeconomic differences are usually summarised in a very simple model, in which socioeconomic status determines more or less the pattern of risk factors, which in turn determines the risk of diseases and mortality (see Figure 1.1). However, such a model does not take into account some other potentially relevant associations especially in studies of the elderly population.

First of all, similar to our analyses, the associations of several *indicators of socioeconomic status* with a specific outcome are often assessed by means of separate analyses. The true situation, however, is much more complex: the various indicators for socioeconomic status are not fully interchangeable, but represent different dimensions of socioeconomic status and could therefore have an independent effect on a certain health outcome. This is particularly problematic when analyses aim at etiologic interpretation with a prospect of subsequent action and intervention. In epidemiological terms this means that a specific indicator of socioeconomic status could be a confounder for the association between another indicator of socioeconomic status and a certain health outcome, as this indicator is correlated with the other indicator of socioeconomic status and has an independent effect on the outcome. Furthermore, they partly indicate the same and can therefore be seen as alternative proxies of the same characteristics of socioeconomic status, or as intermediate factors of each other (see Figure 6.1). For example, the level of income is dependent on occupational level. In most of our analyses we have studied the effect of

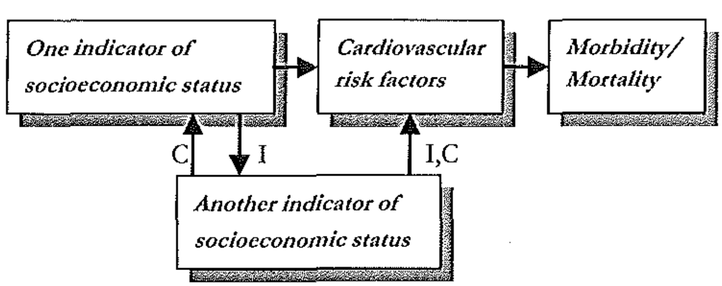


Figure 6.1 An indicator of socioeconomic status as intermediate factor (I) and confounder (C) for the association between another indicator of socioeconomic status and health.

each indicator on a health outcome without adjustment for the other indicators. Adjustment would have theoretically solved the confounding of the other indicators, but if the other indicators were intermediate factors, adjustment for the other indicators would have led to an underestimation of true socioeconomic differences in health. In addition, one could argue that the estimated associations without adjustment already cause underestimation of the relationships between socioeconomic status and health or risk factors, as these associations do not represent all the dimensions of socioeconomic status.

Also in the simplified model, the *time aspect* of the measurements of socioeconomic status, risk factors or health outcomes is neglected. First, in the association between socioeconomic status and mortality it is likely that morbidity acts as an intermediate factor for the association between socioeconomic status at younger ages and mortality. Furthermore, it is likely that morbidity acts as a confounder: someone's morbidity might influence the socioeconomic status when he or she is older and also influence someone's risk to die. This was previously defined in this thesis as selection due to social mobility. Usually, this phenomenon is assumed to have a minor influence on the association between socioeconomic status and health. In our study we concluded that this effect was limited because only minor differences in the risk estimates occurred after prevalent cases of cardiovascular disease were excluded from the study of socioeconomic status with aortic calcification. However, especially at older ages the confounding and intermediary effect of morbidity on socioeconomic differences in mortality could have occurred over a much longer period, from childhood into old age (see Figure 6.2). However, to analyse this in an appropriate way, more advanced method for data assessment with more measurements and alternative statistical techniques, such as G-estimation should be used.[2] This was not possible in our analyses: although more measurements of socioeconomic status in the past were available, accurate measurements of morbidity in the past were lacking.

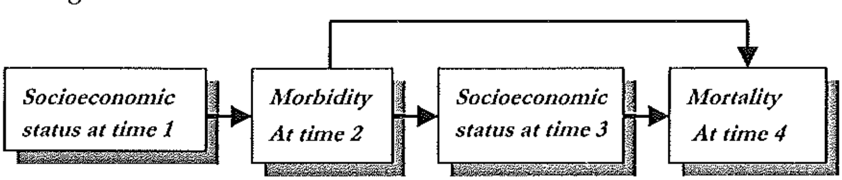


Figure 6.2 Morbidity as an intermediate factor and effect-modifier of the association between socioeconomic status and mortality.

Another disadvantage of this simple model is that only relatively *recent measurements of the risk factors* were taken into account, while in fact the pattern of the risk factors during life might be influenced by socioeconomic status, which in turn could influence the association between socioeconomic status and a health outcome (see Figure 6.3).

Although the measurement of a risk factor at a certain point in time could be considered a proxy of the specific risk factor pattern at younger ages, it is known that the predictive value of risk factors measured at younger ages might be larger compared to its predictive value later in life.[3] In addition, the associations between socioeconomic status and risk factors have changed over time. In the past, cardiovascular risk factors and diseases were possibly more prevalent in higher socioeconomic groups.[4] It is likely that this positive association has additionally affected socioeconomic differences in health at older ages.

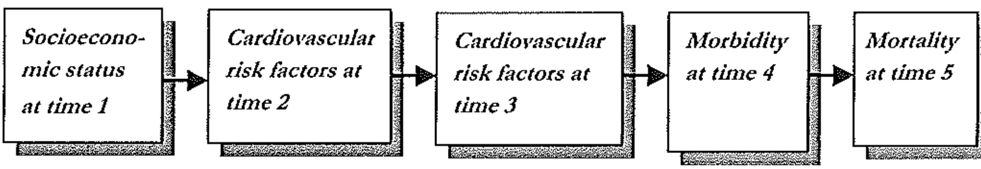


Figure 6.3 *The effect of change in socioeconomic differences in risk factors on the association between socioeconomic status and health.*

6.3.6 Generalisability

The associations in our study were less consistent than expected based on available literature. Can we extrapolate these findings to the Dutch elderly population? In other words, what is the extent of generalisability of our findings?

As mentioned in Chapter 2, the consequence of studying socioeconomic differences in one neighbourhood is that the association between socioeconomic status and health cannot be explained by factors that are shared by everybody, such as health care facilities or living circumstances. In other words, socioeconomic differences in health caused by these factors may remain unnoticed in our setting. It is plausible that in a larger area of The Netherlands the socioeconomic differences in these factors will vary more across socioeconomic groups. Thus, the choice for only one region may have led to less representative results for certain pathways and health outcomes. However, in our view, it is not likely that the associations between socioeconomic status and health outcomes due to the most well known cardiovascular risk factors, such as smoking and diet in the Rotterdam Study, substantially differ from the associations in the rest of The Netherlands. Therefore, in our view the results may be generalised to the Dutch elderly population.

6.4 Explanations

In this paragraph possible explanations for the findings are given. For instance, we try to answer the questions why the results for the three indicators of socioeconomic status differ, why there are differences between the sexes, and why the associations differ from published data.

6.4.1 Explanation for the different associations for indicators of socioeconomic status

Table 6.1 shows that not for all indicators associations with risk factors or health outcomes were found. There are several possible explanations for these differences. It is important to note that the indicators represent in part different aspects of socioeconomic status.[5] Educational level indicates someone's knowledge, ability and willingness to obtain new information. Occupation stands for prestige and occupational hazards, and income indicates material living conditions and resources. As for being at risk of a certain risk factor, other aspects of socioeconomic status might have played a role. It is likely that some risk factors are related to someone's knowledge, whereas others are more strongly influenced by material resources.

Secondly, the different associations across the various indicators of socioeconomic status are partly the result of cut-off points for the different categories of socioeconomic status.[6] For example, the lowest education group comprises 60% of the study population, while the lowest income group comprises 20% of the study population. Given a dose-response relationship between socioeconomic status and health, this different cut-off point will affect the socioeconomic differences in health.

Lastly, differences in impact of the socioeconomic indicators may change over time. In our study population, the indicators 'education' and 'occupation' were based on an individual's achievement of years ago and are assumed to have remained stable for years. Income, on the other hand, may have been changed even recently, making it a more accurate indicator of current socioeconomic status. If socioeconomic circumstances early in life influence people's health when they are older, there will be a strong association with education, while stronger associations will be seen for occupation and income in the case of a strong impact of current socioeconomic circumstances.

To identify which explanation is responsible for each specific result is difficult. For example, the stronger associations for dietary habits, smoking and other risk factors across educational groups among women could be due to a small reference group of higher educated women, but may also suggest that knowledge is more important for these risk factors. Among men, income quite often yielded the strongest association, which may suggest that current socioeconomic status is important for socioeconomic differences in health. It may, however, also suggest that material aspects are important.

6.4.2 Explanations for inconsistencies in associations

Although some strong associations were found for women, the associations in general were less pronounced than expected. These weaker findings might be the result of several kinds of bias, leading to an underestimation of the true associations, as discussed above. However, assuming that the results are valid, two main explanations can be given for the weaker findings.

It is possible that the expectation of large socioeconomic differences was not justified. This might be due to a differential selection of positive studies on socioeconomic differences in health. Research groups may have submitted only strong associations to scientific journals, thereby causing publication bias.

An alternative explanation is also possible, namely that socioeconomic differences at older ages are generally not the same as at younger ages.[7] In fact, the analyses in the Whitehall Study showed that at older ages, relative differences across socioeconomic groups become less pronounced. In addition, due to the higher morbidity and mortality rates in the older population and more competing causes of death, relative risks will decline anyway compared with those at younger ages. Besides that, inequalities at younger ages will have eliminated the more vulnerable individuals from the population. Due to selective mortality, socioeconomic differences in health will be less pronounced at older ages. Furthermore, the distribution of some risk factors will become more equal across the different socioeconomic groups at older ages. For example, the direct effect of the working environment has disappeared.[8] This will apply at least to some extent, because the differences found in the Rotterdam Study were smaller compared to those in the first Whitehall Study. Therefore, it is possible that The Netherlands, a welfare state with a public retirement system and health care available to all citizens, has a better social and health care profile compared to the United Kingdom and other western countries. This hypothesis is not in line with a European comparison of socioeconomic differences in health among middle-aged persons, in which Dutch socioeconomic health differences were not significantly smaller compared to other countries.[9] However, this particular study was performed among middle-aged persons. For older people, several factors such as health care facilities might well be different.

6.4.3 Explanations for the differences between men and women

The associations that we found were not similar for men and women. For example, women in the lower socioeconomic groups more often suffer from stroke and aortic calcification, while this appeared not the case among men. Why is that?

First of all, one may question whether it would be reasonable that the associations be the same. Despite the general idea of a worse risk profile among the lower socioeconomic groups, it does not mean that the associations should quantitatively be the same for both sexes. For example, women have a different risk profile for several diseases, different access to and quality of health care, a different pattern of exposures at work, a different death-cause pattern and a different life expectancy.

Still, the question remains why analyses among women showed a more generalised phenomenon of socioeconomic differences in health whereas findings for men were inconsistent. Other studies have observed smaller as well as larger socioeconomic differences in health for women compared to men.[9,10][Mackenbach et al, unpublished data] As most explanatory studies have focussed on men, not much is known about this discrepancy.

In addition, it is possible that the elimination of the most vulnerable individuals of the population has had a larger influence on men than on women. This results from a higher morbidity and mortality among middle-aged men compared to women,[11] and from the presence of socioeconomic differences among middle-aged persons in The Netherlands.[12]

6.4.4 Explanations for the minor role of conventional risk factors in socioeconomic differences in health

In contrast to other studies where risk factors partly explain the socioeconomic differences in health,[13-16] the distribution of risk factors across socioeconomic groups could explain only a minor proportion of the socioeconomic differences in health in the Rotterdam Study.

First, it is possible that the limited explanation is caused by the selection of intermediate risk factors or other health outcomes. It is also possible that the associations between socioeconomic status and risk factors were diluted due to the inaccuracy that is inherent to the use of single measurements of risk factors as a proxy of lifetime exposure. Alternatively, socioeconomic differences in risk factors decrease because of differential mortality. High-risk subjects die earlier in time, even more so in lower socioeconomic groups.[8] Furthermore, it is possible that risk factors other than those presented in this study are responsible for the differences. For example, deprivation in childhood, infectious diseases, psychosocial factors, living circumstances, psychosocial stress, social support, or factors at aggregate level, may all have had an effect.

6.5 Implications for health policy

For the Dutch elderly population, socioeconomic differences were not found for all the risk factors and diseases, but for women all associations did point in the same direction: lower socioeconomic groups were generally worse off. Among men, these differences were less consistent, possibly as a consequence of socioeconomic differences in health at younger ages.

In all societies, some are better off than others, also with respect to their health. Since some of these differences cannot be avoided,[17] one could argue that in The Netherlands socioeconomic inequalities among elderly people should not be a major concern for health policy makers. However, not all inequalities in health are unavoidable or the result of free choice. From a public-health point of view, policy measures in order to reduce these inequalities are desirable. In addition, taking into account the large numbers of the lower socioeconomic groups, a marked improvement in public health can be achieved by means of effective policy.

Whether the observed socioeconomic differences are small or large is a political rather than a research judgement. But if we assume that policy makers aim to improve public health in a society and promote equalities in opportunities for health, several implications can be derived from our study. Measures could target the elderly population, but a much bigger health gain would be achieved when health policy is directed towards younger age groups, particularly because socioeconomic differences in health at older ages also reflect a legacy of the past. However, in order to decrease socioeconomic inequalities in the prevailing elderly population, it is also important to have policy measures directed towards older ages. We distinguish two main areas in which measures could be taken: policy measures to improve socioeconomic status and measures to establish a more equal distribution of risk factors across socioeconomic groups. In fact, several of such policy measures are already performed by health policy makers.[18]

It is useful to focus on social structure in order to prevent the development of risk factors.[19] Rose reported that 'The primary determinants of disease are mainly economic and social, and therefore its remedies must also be economic and social'.[20] Consequently, policies to improve health of the disadvanced go beyond health policy measures. For example, an increase in the basic income of retired people or a contribution towards the costs of living or health care could be considered within this respect. Also policy measures to improve socioeconomic status already at younger ages are important. People could, for example, be encouraged to continue into higher education, because education at younger ages will have an impact on elderly people's health.[21]

Other policy measures could focus on a change in the distribution of risk factors. Generally, our data show the presence of modest socioeconomic differences in risk factors among Dutch elderly people. The biological significance of most of the observed differences by socioeconomic groups in isolation is limited. Nevertheless, from a public-health point of view, and since it affects large segments of the population, several modest changes to multiple risk factors may result in quite a significant health change in the population. This applies not only to cardiovascular disease, which we studied here, but also to the occurrence of other diseases, as most cardiovascular risk factors are also risk factors for other diseases.

Here again, one should try to improve the situation at younger ages, so that improvements in health are achieved at both younger and older ages. However, also in an elderly population a change in risk profile might reduce the risk of mortality, or increase a healthy life expectancy and perhaps quality of life. Examples of interventions to improve socioeconomic differences in health may include health education to improve dietary habits in the lowest socioeconomic groups, control of body weight, changing smoking habits or enhanced screening and treatment strategies for risk factors such as cholesterol or hypertension. These interventions should be directed to specific target populations. For example, the provision of information alone is probably sufficient for the higher socioeconomic groups, while a combination of information and personal guidance may appear to be more effective for the lower socioeconomic groups.[18]

6.6 Further research

Research always generates more questions than answers. First, more data on the effect of socioeconomic status at the individual and aggregate levels should be obtained to clarify the impact of social structure on health. Furthermore, more attention should be paid to data collection and data analyses of repeated measurements of socioeconomic status, risk factors, and health outcomes. Only with more advanced analysis methods, such as G-estimation, it is possible to disclose the mechanisms behind socioeconomic differences. Also, research should be intensified with regard to the measurement of socioeconomic status among women. For example, would 'occupation of head of the household' also be a good indicator for younger birth cohorts, now that the employment market has changed and more people are in paid employment?

For the Dutch elderly population, a complete description of socioeconomic inequalities in health has not yet been achieved. In the Rotterdam Study, for example, it would be possible to carry out the same analyses with more statistical power when the follow-up period was extended. With more events and person-time it would also be feasible to stratify on other factors such as age in order to elucidate socioeconomic differences according to these factors. Furthermore, it would be possible to examine socioeconomic differences for other specific diseases. In addition, it would be interesting to study the effect of socioeconomic status on a healthy life expectancy and quality of life among elderly people. In addition to the description of the socioeconomic differences in health, we support studies that focus on the question why the lower socioeconomic groups have a worse risk profile, such as smoking or being overweight. In other words, how is socioeconomic status causally related to several risk factors of diseases? Only then targeted interventions can be proposed. Furthermore, we must continue the research concerning the best interventions to reduce inequalities in disease occurrence and outcome.

6.7. Final remark

In conclusion, we hope that our analyses will contribute to a continuous and productive debate on socioeconomic differences in people's health at older ages. There is sufficient evidence to believe that socioeconomic inequalities in cardiovascular disease and mortality among the Dutch elderly population are present, although they are likely to be smaller than at younger ages and probably less pronounced than in some other westernized societies.

6.8 References

1. World Health Organisation. *Health for all targets. The health policy for Europe.* Copenhagen: WHO, 1993.
2. Robins J. The control of confounding by intermediate variables. *Stat Med* 1989;8:679-701.
3. Shipley MJ, Pocock SJ, Marmot MG. Does plasma cholesterol concentration predict mortality from coronary heart disease in elderly people? 18 year follow up in Whitehall study. *BMJ* 1991;303:89-92.
4. Kunst AE. *Sociale ongelijkheid en hart- en vaatziekten: een literatuurstudie [in Dutch].* Rotterdam: Instituut Maatschappelijke Gezondheidszorg, Erasmus Universiteit, 1990.
5. Liberatos P, Link BG, Kelsey JL. The measurement of social class in epidemiology. *Epidemiol Rev* 1988;10:87-121.
6. Davey Smith G, Bartley M, Blane D. The Black report on socioeconomic inequalities in health 10 years on. *BMJ* 1990;301:373-7.
7. Jefferys M. Social inequalities in health-do they diminish with age? *Am J Public Health* 1996;86:474-5.
8. van de Mheen PJ. *Facts and artefacts. Variation in risk factor and the impact on estimated potential health benefits* [Dissertation]. Amsterdam: University of Amsterdam, 1997.
9. Mackenbach JP, Kunst AE, Cavelaars AE, Groenhof F, Geurts JJ. Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet* 1997;349:1655-9.
10. Stronks K, van de Mheen H, van den Bos J, Mackenbach JP. Smaller socioeconomic inequalities in health among women: the role of employment status. *Int J Epidemiol* 1995;24:559-68.
11. C.B.S. (Dutch Central Bureau of Statistics). *Statistisch Jaarboek 1997 [in Dutch].* Voorburg/Heerlen: CBS, 1997.
12. Mackenbach JP. Socioeconomic inequalities in health in the Netherlands: impact of a five year research programme. *BMJ* 1994;309:1487-91.

13. Lynch J, Kaplan GA, Cohen RD, Tuomilehto J, Salonen JT. Do cardiovascular risk factors explain the relation between socioeconomic status, risk of all-cause mortality, cardiovascular mortality and acute myocardial infarction. *Am J Epidemiol* 1996;144:934-42.

14. Marmot MG, Rose G, Shipley M, Hamilton PJ. Employment grade and coronary heart disease in British civil servants. *J Epidemiol Community Health* 1978;32:244-9.

15. Diez-Roux AV, Nieto FJ, Tyroler HA, Crum LD, Szklo M. Social inequalities and atherosclerosis. The atherosclerosis risk in communities study. *Am J Epidemiol* 1995;141:960-72.

16. Lynch J, Kaplan GA, Salonen R, Cohen RD, Salonen JT. Socioeconomic status and carotid atherosclerosis. *Circulation* 1995;92:1786-92.

17. Stronks K. *Socio-economic inequalities in health: individual choice or social circumstances?* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1997.

18. Gepkens A, Gunning-Schepers LJ. Interventions to reduce socioeconomic health differences; a review of the international literature. *Eur J Public Health* 1996;6:218-26.

19. Kaplan GA. Where do shared pathways lead? Some reflections on a research agenda. *Psychosom Med* 1995;57:208-12.

20. Rose G. *The strategy of preventive medicine.* Oxford: Oxford University Press, 1992.

21. van de Mheen D. *Inequalities in health, to be continued? A life-course perspective on socio-economic inequalities in health* [Dissertation]. Rotterdam: Erasmus University Rotterdam, 1998.

Summary

Studies carried out in several Western societies have shown that people in a lower socioeconomic position suffer from more diseases and have a shorter life expectancy than people have in a higher socioeconomic position. Although socioeconomic inequalities in health occur at any age, from birth into old age, most studies have been done among persons who are younger than 65. Since mortality rates and morbidity rates have declined in younger age groups, their health inequalities are losing significance and meaning, whereas health inequalities among the growing number of elderly people are gaining in importance.

The aim of the studies in this dissertation was to study socioeconomic differences in health among elderly people with the focus on the socioeconomic differences in all-cause mortality and cardiovascular disease. In addition, it was examined whether there are socioeconomic differences in cardiovascular risk factors that might explain the association between socioeconomic status and cardiovascular morbidity or mortality among elderly men and women.

The research has mainly been conducted as part of the Rotterdam Study, a prospective follow-up study among 7,983 men and women aged 55 years and over who live in a suburb of Rotterdam and who attended the initial screening between 1990 and 1993. In **Chapter 2** a description of the socioeconomic status of this Dutch elderly population is given. Socioeconomic status was assessed at baseline on the basis of the indicators 'education', 'occupation' and 'income'. On average, men had a higher socioeconomic status than women. In the study population of the Rotterdam Study, all socioeconomic groups were represented. However, because a number of factors, such as neighbourhood conditions, housing conditions or health care services, are largely similar for everybody, accounting for socioeconomic inequalities in health in the total population, some of the socioeconomic differences in health remained undetected. A small part of the research was conducted as part of the British first Whitehall Study. This study is a follow-up study of 18,001 British male civil servants aged 40-69 who attended the initial screening between 1967 and 1970.

In **Chapter 3** a description is given of the relationship between socioeconomic status and mortality in the Rotterdam Study and in the First Whitehall Study. Data on mortality

were obtained for all participants in the Rotterdam Study from the municipal population registry and general practitioners. Relative risks of mortality by indicators of socioeconomic status were estimated after an average follow-up period of 4.1 years. Mortality risks were higher for lower educated men (relative risk (RR)=1.4), unskilled manual workers (RR=1.4) and those with a lower equivalent household income (RR=1.7). For women, the relative risks of mortality were also higher for lower educated groups (RR=2.0), but lower equivalent household income and occupational status appeared not to be related. The findings in this study indicate that there are clear differences in mortality across groups with different socioeconomic status (**Chapter 3.1**).

The association between socioeconomic status and mortality rates for all major causes of death for middle-aged and elderly men was analysed in the First Whitehall Study (**Chapter 3.2**). After a follow-up of more than 25 years, employment grade differences are still present in all cause mortality (RR=2.1) and for nearly all specific causes of death. Main risk factors could explain only one third of this gradient. Comparing the older retired group with the younger pre-retirement group, the differentials in mortality remained for almost all causes of deaths, although the differentials were less pronounced (RR for all cause mortality =1.7 and 2.9 respectively). The largest decline was seen for chronic bronchitis (RR=30 versus RR=8.3), gastrointestinal diseases (RR=10 versus RR=2.2) and genito-urinary diseases (RR=9.4 versus RR=2.6).

Also in the first Whitehall Study, the effect of season on all cause and cause specific mortality was determined and the question was answered whether high-risk groups for seasonal effects can be identified (**Chapter 3.3**). There were seasonal effects for mortality due to all causes (winter versus summer rate ratio 1.2), respiratory disease (RR = 2.0) and ischaemic heart disease (RR= 1.3). Ischaemic heart disease, the commonest cause of death, contributed the largest part of the absolute difference in all cause winter excess mortality. There was no evidence that high-risk groups are subject to greater seasonal variations in mortality: the excess of death in winter was greater among older people, because they were dying (also in summer) more of seasonal sensitive diseases; low civil service employment grade was not associated with higher seasonality in mortality than high employment grade; and participants identified as high risk for mortality due to cardiovascular diseases had greater seasonality in stroke mortality than those at low risk, although there was no effect of risk group on all cause or ischaemic heart disease mortality. However, participants with cardiovascular disease showed greater seasonality from all cause mortality and from the seasonal sensitive diseases. Further research should specify possibilities of focussing the interventions on the whole population and those already diseased in order to prevent these seasonal deaths.

The association between socioeconomic status and some cardiovascular diseases is discussed in **Chapter 4**. As studies on subclinical manifestations of atherosclerotic diseases are limited in number and have not been carried out among elderly persons, the relationship is investigated between socioeconomic status and aortic atherosclerosis among elderly people (**Chapter 4.1**). Atherosclerosis was estimated by calcified deposits in the abdominal aorta. Aortic atherosclerosis was more common among women in lower educational and occupational strata. The lowest educated group and the lowest occupation group had an increased risk of aortic atherosclerosis compared to the highest groups (odds ratios are 1.3 and 1.3, respectively). The odds ratios for severe atherosclerosis for women in the lowest socioeconomic strata compared to the highest strata were 1.6 for education, 2.8 for occupation and 1.7 for income. After exclusion of persons with a history of cardiovascular disease, the same trends still emerged. Among men no relationships were observed. These findings show that socioeconomic status is related to aortic atherosclerosis in women, which suggests that socioeconomic status affects the incidence of cardiovascular disease before its clinical manifestation.

The association between socioeconomic status and stroke was emerged in cross-sectional and longitudinal data of 4,274 female participants of the Rotterdam Study and is discussed in **Chapter 4.2**. A history of stroke was much more common among women in lower socioeconomic strata. The same trend was observed for the relationship between the lowest socioeconomic groups and the incidence of stroke. Risk factors for stroke were not related to socioeconomic status in a consistent manner. Smoking, a history of cardiovascular disease, and being overweight were more common in lower socioeconomic groups. However, socioeconomic differences in hypertension, anti-hypertensive drug use, prevalence of atrial fibrillation and prevalence of left ventricular hypertrophy were not observed. The complex of established risk factors could not explain the association between socioeconomic status and stroke. Our findings indicate that not only the actual risk profile but also risk factors earlier in life may be of importance.

In **Chapter 4.3** the association between income and myocardial infarction and cardiac mortality was described for men. In addition, a distinction between the fatal and non-fatal first myocardial infarctions. Cardiac mortality was defined as deaths due to acute coronary disease and or death due to heart failure. The risk of cardiac death in the lowest income quartile was two and a half times higher compared to the highest income group. The prevalence of myocardial infarction tended to be higher in the lower income groups. Incidence of non-fatal myocardial infarction was not related to income, while a fatal myocardial infarction occurred more often in the lower income groups (not statistically significant). Thus, income affects the risk of surviving a myocardial infarction.

Different frequencies of cardiovascular risk factors across socioeconomic groups such as unfavourable dietary habits, might explain the socioeconomic differences in cardiovascular disease. The explanation of socioeconomic differences in health by a number of risk factors is generally discussed in Chapter 4, and two risk factors are discussed in detail in Chapter 5. In **Chapter 5.1**, a description is given of the dietary intake according to educational groups. In general, the dietary differences between socioeconomic groups were small. Lower educated subjects had a higher intake of almost all macronutrients compared with higher educated subjects. Furthermore, fat composition was more adverse in the lower educated strata; in lower educated subjects, relatively more energy was derived from saturated fat, the P:S ratio was lower and the intake of cholesterol higher. These differences could be explained by a higher intake of visible fat and more meat consumption. In addition, the composition of these products differed: the higher educated used relatively more lean meat and low-fat milk products. Furthermore, the intake of fibres was lower among the lower educated. Among lower educated groups there were more abstainers and the type of alcoholic beverages also differed between the groups. Intake of antioxidants from food alone did not differ between educational groups. Thus, in Dutch elderly people, there are socioeconomic differences in dietary intake. Although these differences are small, the findings support the role of diet in the explanation of socioeconomic inequalities in cardiovascular health.

In **Chapter 5.2** the prevalence, level of treatment and control of hypertension by age and sociodemographic factors are given. Prevalence of hypertension was based on blood pressure levels (160/95 mmHg) and use of blood pressure lowering drugs for the indication of hypertension, type of treatment and control of hypertension. This study showed that systolic blood pressure rises with age, while diastolic blood pressure levels off. The prevalence of hypertension increases with age and was higher among women than among men. About 80% of the hypertensives were aware of having hypertension from which 82% was treated. For 70% of those, treatment was adequate with reference to conservative criteria. Hypertension was more prevalent among persons not living in an elderly home, higher educated men and lower educated women. Persons without a partner and men living in an elderly home had a higher risk of being unaware of or not being treated for their hypertension. Treatment was more often successful among those living in an elderly home. In other words, the prevalence of hypertension is higher among older women and increases with age in both sexes. A large number of hypertensive elderly people is aware of their condition and is treated for hypertension. Nevertheless, hypertension is not adequately controlled for the majority of hypertensives (56%). Therefore this group needs to be paid in medical practices in order to reduce the burden of cardiovascular disease in elderly people.

Our results are briefly summarised in **Chapter 6** and the limitations and strengths of the study are also considered. First, the study population is discussed: the effect of non-response and sample size, the measurement of socioeconomic status, risk factors and health are considered. Furthermore, attention is paid to the method of analysis by discussing refinements on the conceptual model for the association between socioeconomic status and health. The generalisability of our findings is also discussed. In addition, we tried to answer the questions why results for the three indicators of socioeconomic status differ, why there are differences between the sexes and why the associations differ from published data. Some implications of our study for health policy and ideas for future research are given.

In conclusion, socioeconomic differences were found in mortality and some cardiovascular diseases. However, we did not find socioeconomic differences for all the diseases and risk factors. Except for stroke, the socioeconomic differences in diseases and risk factors were not big. Among women, all associations pointed into the same direction, namely the risk profile of elderly women in the lower socioeconomic groups is worse, they suffer from more diseases and have a shorter life expectancy. The risk factors could only explain a small proportion of the associations. This picture was less clear for men.

Hopefully these analyses will contribute to a continuous and productive debate on socioeconomic differences in people's health at older ages. There is sufficient evidence to believe that socioeconomic inequalities in cardiovascular disease and mortality among the Dutch elderly population are present, although they are likely to be smaller than at younger ages and probably less pronounced than in some other westernised societies.

Samenvatting

Onderzoek in verschillende Westerse landen heeft aangetoond dat mensen uit de lagere sociaal-economische groepen vaker ziek zijn en een kortere levensverwachting hebben dan mensen uit de hogere sociaal-economische groepen. Alhoewel sociaal-economische verschillen in gezondheid op iedere leeftijd voorkomen, vanaf de geboorte tot op hoge leeftijd, zijn de meeste studies uitgevoerd bij personen jonger dan 65 jaar. Sociaal-economische verschillen in deze leeftijdsgroep worden minder belangrijk, omdat sterfte en ziekte bij hen afneemt. Daarentegen worden sociaal-economische gezondheidsverschillen in de vergrijzende samenleving steeds belangrijker.

Het doel van het onderzoek in dit proefschrift was het beschrijven van de sociaal-economische gezondheidsverschillen bij ouderen en dan met name de verschillen in het voorkomen van hart- en vaatziekten en sterfte. Verder is onderzocht of er sociaal-economische verschillen bestaan in het voorkomen van de risicofactoren voor hart- en vaatziekten. Deze risicofactoren zouden kunnen verklaren waarom er verschillen zijn in het voorkomen van hart- en vaatziekten en sterfte tussen de sociaal-economische groepen.

Het onderzoek is voornamelijk uitgevoerd binnen het ERGO-onderzoek. Dit is een prospectief vervolg-onderzoek bij 7.983 mannen en vrouwen van 55 jaar en ouder uit Ommoord, een wijk van Rotterdam. De eerste onderzoeksronde vond plaats tussen 1990 en 1993. In **hoofdstuk 2** wordt een beschrijving gegeven van de sociaal-economische status van de onderzoeksgroep. De sociaal-economische status is gemeten met de indicatoren 'opleiding', 'beroep' en 'inkomen'. Mannen hadden gemiddeld een hogere sociaal-economische status dan vrouwen. In de studiepopulatie van het ERGO-onderzoek waren alle sociaal-economische groepen vertegenwoordigd. Echter, een aantal factoren zoals buurtomstandigheden, woonomstandigheden, en het gebruik van de gezondheidszorg zullen voor vrijwel iedereen gelijk zijn. Aangezien een deel van de sociaal-economische verschillen in gezondheid wordt veroorzaakt door deze factoren, is het mogelijk dat in Ommoord de gezondheidsverschillen kleiner zijn. Een gedeelte van het onderzoek in dit proefschrift is uitgevoerd binnen de 'Whitehall Study'. Dit is een vervolgonderzoek dat gestart is tussen 1967 en 1970 onder 18.001 mannelijke Britse ambtenaren (40-69 jaar).

In **hoofdstuk 3** worden de sociaal-economische verschillen in sterfte beschreven. Deze zijn gemeten in het ERGO-onderzoek en in de eerste Whitehall Study. Sterftegegevens voor alle deelnemers van het ERGO-onderzoek zijn verkregen via de gemeentelijke registratie en de huisartsen. De gemiddelde onderzoeksperiode was 4,1 jaar. De kans op vroegtijdig overlijden was hoger voor lager opgeleide mannen, (relatief risico (RR)=1,4), handarbeiders (RR=1,4) en mannen met het laagste equivalente huishoudinkomen (RR=1,7) vergeleken met de hogere sociaal-economische groepen. Ook voor vrouwen was het relatieve risico op sterfte hoger voor de lager opgeleiden (RR=2,0). Echter, inkomen en beroep bleken niet samen te hangen met de kans op vroegtijdig overlijden. De resultaten in dit hoofdstuk geven dus aan dat er duidelijke sociaal-economische sterfteverschillen bestaan (**hoofdstuk 3.1**).

De samenhang tussen sociaal-economische status en verschillende doodsoorzaken is onderzocht onder mannelijke ambtenaren van middelbare en oudere leeftijd in de eerste Whitehall Study (**hoofdstuk 3.2**). Na meer dan 25 jaar vervolgonderzoek zijn er tussen de beroepsniveaus verschillen in totale sterfte (RR= 2,1) en in alle doodsoorzaken gevonden. Bekende risicofactoren, zoal cholesterol, roken en bloeddruk, konden slechts een derde van deze verschillen verklaren. Vergelijken we de oudste leeftijdsgroep (70-plussers) met de jongste groep (40-65 jaar), dan zijn op oudere leeftijd de sociaal-economische verschillen voor de meeste specifieke doodsoorzaken kleiner, maar nog steeds aanwezig (relatief risico voor totale sterfte is 2,9 voor de jongste groep en 1,7 voor de oudste groep). De grootste afname was te zien voor sterfte aan chronische bronchitis (RR=30 versus RR=8,3) en gastro-intestinale ziekten (RR=10 versus RR=2,2).

Ook het effect van seizoen op sterfte in het algemeen en voor verschillende doodsoorzaken is onderzocht in de eerste Whitehall Study. Daarnaast is getracht om te bepalen of er risicogroepen zijn die gevoeliger zijn voor het effect van seizoen. (**hoofdstuk 3.3**). Er bleek seizoensvariatie in sterfte te bestaan (winter versus zomer RR=1,2). Dit was het sterkst voor ziekten aan het ademhalingssysteem (RR=2,0). Echter, hart- en vaatziekten (RR = 1.3), de meest voorkomende doodsoorzaak, droeg het meest bij aan de absolute verschillen in het aantal doden tussen de zomer en de winter. Er bleek niet duidelijk dat risicogroepen gevoeliger waren voor de invloed van seizoen. Weliswaar gaan is het verschil tussen het aantal doden in de zomer en de winter groter voor de oudere leeftijdsgroepen vergeleken met de jongere leeftijdsgroepen, maar dit komt doordat in deze oudere groepen meer mensen dood gaan aan seizoensgevoelige ziekten (ook in de zomer). De seizoensvariatie in sterfte hing niet samen met beroepsklasse. Personen die gekenmerkt werden door een hoger risico op het het krijgen van hart- en vaatziekten waren gevoeliger voor het effect van seizoen op sterfte door een beroerte vergeleken met de mensen die gekenmerkt worden met een lager risico. Deze groepen verschilden niet in het seizoenseffect op totale sterfte en sterfte aan hart- en vaatziekten. Wel waren mensen met hart- en vaatziekten gevoeliger voor het effect van seizoen.

Verder onderzoek zou zich moeten richten op de mogelijkheden van preventieve interventies voor de gehele bevolking en de zieken.

De samenhang tussen sociaal-economische status en verschillende hart- en vaatziekten is gerapporteerd in **hoofdstuk 4.** In **hoofdstuk 4.1** is het verband tussen sociaal-economische status en een subklinische vorm van atherosclerose beschreven. Atherosclerose werd bepaald aan de hand van de aanwezigheid van verkalkte plaques in de abdominale aorta. Dit kwam meer voor bij vrouwen met een lager opleidings- en beroepsniveau. De laagste opleidingsgroep en de laagste beroepsklasse hadden een hogere risico op atherosclerose van de aorta vergeleken met de hogere groepen (odds ratios waren 1,3 voor beide indicatoren). De odds ratios voor ernstige atherosclerose voor vrouwen in de laagste sociaal-economische strata vergeleken met de hoogste strata waren 1,6 voor opleiding, 2,8 voor beroepsklasse en 1,7 voor inkomen. Na uitsluiting van personen met hart-en vaatziekten in het verleden, werden dezelfde trends gevonden. Voor mannen zijn er geen verbanden gevonden. Deze bevindingen suggereert dat voor vrouwen, sociaal-economische status invloed heeft op de incidentie van hart- en vaatziekten in een vroeg stadium: al voordat er klinische symptomen optreden.

De samenhang tussen sociaal-economische status en de prevalentie en incidentie van beroerte is onderzocht onder 4.274 vrouwen van het ERGO-onderzoek en wordt beschreven in **hoofdstuk 4.2.** Relatief meer vrouwen uit de lagere sociaal-economische klassen hadden in het verleden een beroerte gehad. Dezelfde trend werd gezien voor het verband tussen lagere sociaal-economische status en de incidentie van beroerte. Risicofactoren voor beroerte waren niet consistent gerelateerd aan sociaal-economische status. Roken, het hebben gehad van hart- en vaatziekten en overgewicht kwamen meer voor in de lagere sociaal-economische groepen. Er werden geen sociaal-economische verschillen gevonden voor hypertensie, medicijngebruik voor hypertensie, atriumfibrilleren en linker ventrikel hypertrofie. Deze bekende risicofactoren konden niet de relatie tussen sociaal-economische status en beroerte verklaren. Deze bevindingen suggereren dat niet het huidige risicoprofiel, maar ook de risicofactoren gedurende het hele leven belangrijk zijn.

In **hoofdstuk 4.3** is het verband tussen inkomen en hartinfarct en cardiale sterfte voor mannen beschreven. Bovendien is er onderscheid gemaakt in fatale en niet-fatale hartinfarcten. Cardiale sterfte was gedefinieerd als overlijden ten gevolge van acute ischaemische hartziekte, (inclusief een hartinfarct, plotselinge dood waarbij een cardiale oorzaak niet uit te sluiten is) en hartfalen. Mensen in het laagste quintiel van inkomen hadden een twee en een half keer zo hoog risico om te overlijden aan een cardiale doodsoorzaak vergeleken met personen in de hoogste inkomensgroep. De prevalentie van een hartinfarct was hoger in de lagere inkomensgroepen. De incidentie van een niet-fataal hartinfarct was niet gerelateerd aan inkomen, terwijl een fataal hartinfarct vaker voorkwam in de lager inkomensgroepen. Inkomen heeft dus invloed op de overlevingskans na een hartinfarct.

Variatie in het voorkomen van risicofactoren voor hart- en vaatziekten tussen de verschillende sociaal-economische groepen zouden de sociaal-economische verschillen in hart- en vaatziekten kunnen verklaren. Gedeeltelijk is dit al besproken in hoofdstuk 4, echter in hoofdstuk 5 worden twee risicofactoren in meer detail besproken. In **hoofdstuk 5.1** wordt een beschrijving gegeven van de voedingsinname naar opleidingsniveau. Over het algemeen zijn de verschillen tussen de opleidingsgroepen klein. Lager opgeleiden hebben een grotere inname van bijna alle macronutriënten vergeleken met de hoger opgeleiden. Verder is de vetinname minder gunstig van samenstelling voor de lager opgeleiden:een grotere inname van verzadigd vet, een lagere ratio van meervoudig onverzadigd vet versus verzadigd vet, en een hogere cholesterolinname. Deze verschillen komen onder andere door een grotere inname van zichtbaar vet en een hogere vleesconsumptie. Verder verschilt de samenstelling van deze produkten: de hoger opgeleiden consumeren relatief meer mager vlees en magere of half-volle melk(produkten). Tenslotte worden door de lager opgeleiden minder vezels gegeten. Niet drinken van alcohol komt vaker voor in de lager opgeleide groep. Daarnaast zijn er onder de alcoholdrinkers ook verschillen in het type alcoholische drank dat wordt gedronken. Inname van antioxidanten uit voedingsmiddelen alleen verschillen niet naar opleiding. Dus er zijn sociaal-economische verschillen in voedingsinname onder Nederlandse ouderen. Ondanks dat deze verschillen klein zijn, ondersteunt dit het idee dat voeding een rol kan spelen in de verklaring van de sociaal-economische verschillen in hart- en vaatziekten.

In **hoofdstuk 5.2** is de prevalentie, behandeling en controle van hypertensie naar leeftijdsgroep of sociaal-demografische factoren weergegeven. Prevalentie van hypertensie is gebaseerd op bloeddrukmeting (160/95 mmHg) en gebruik van bloeddrukverlagende medicatie voor hypertensie. Dit onderzoek geeft aan dat systolische bloeddruk stijgt met de leeftijd terwijl de diastolische bloeddruk afneemt met de leeftijd. De prevalentie van hypertensie neemt toe met de leeftijd en was hoger onder vrouwen dan onder mannen. Ongeveer 80% van de hypertensieven waren bewust dat ze hypertensie hadden. Hiervan werd 82% behandeld en daarvan was het in 70% van de gevallen een adequate behandeling. Onder thuiswonende ouderen, hoger opgeleide mannen en lager opgeleide vrouwen kwam hypertensie vaker voor. Relatief meer alleenstaanden en mannen in een verzorgingshuis waren zich niet bewust van hun te hoge bloeddruk, en daarvan werd een groter gedeelte niet behandeld voor hun hypertensie. Behandeling van hypertensie was vaker succesvol bij mensen in een verzorgingshuis. De bevindingen in dit hoofdstuk geven aan dat de meerderheid van de hypertensieven (56%) hun te hoge bloeddruk niet onder controle heeft. Deze groep verdient meer aandacht in de medische praktijk.

In **hoofdstuk 6** worden de resultaten kort samengevat en worden de beperkingen en de sterke kanten van het onderzoek besproken. Allereerst is de onderzoekspopulatie bediscussieerd: het effect van de non-respons en steekproefgrootte, de meting van sociaal-economische status en de meting van de risicofactoren en hart- en vaatziekten. Verder is er aandacht besteed aan de analysemethode door verfijningen aan te brengen in het model van sociaal-economische status en gezondheid. Daarnaast is ingegaan op de generaliseerbaarheid van de bevindingen.

Bovendien is getracht antwoord te geven op de vraag waarom de resultaten verschillen voor de indicatoren van sociaal-economische status, waarom de resultaten voor mannen en vrouwen anders zijn en waarom de bevindingen anders zijn dan eerder gepubliceerde gegevens. Ook worden enkelen aanbevelingen voor beleid en verder onderzoek gegeven.

Samenvattend kunnen we concluderen dat er sociaal-economische verschillen in sterfte en enkele hart- en vaatziekten zijn gevonden. Maar, we vonden niet voor alle ziekten en risicofactoren voor hart- en vaatziekten sociaal-economische verschillen. De sociaal-economische verschillen in gezondheid waren niet groot, behalve voor het voorkomen van beroerte. De associaties waren voor vrouwen allemaal in dezelfde richting: oudere vrouwen uit de lagere sociaal-economische groepen hadden een slechter risicoprofiel, waren vaker ziek en hadden een kortere levensverwachting. De risicofactoren konden slechts een klein deel van de sociaal-economische gezondheidsverschillen verklaren. Voor mannen waren de resultaten minder consistent.

Hopelijk dragen deze analyses bij aan de discussie over sociaal-economische gezondheidsverschillen op oudere leeftijd. Er is voldoende bewijs om te concluderen dat er sociaal-economische ongelijkheden in gezondheid onder Nederlandse ouderen bestaan. Wel zijn de verschillen minder uitgesproken dan op jongere leeftijd en waarschijnlijk kleiner dan in andere westerse landen.

List of publications

Manuscripts based on the results presented in this thesis

Chapter 3

CTM van Rossum, H van de Mheen, JP Mackenbach, DE Grobbee. Socioeconomic status and mortality in Dutch elderly people. The Rotterdam Study. (Submitted)

CTM van Rossum, M Shipley, H van de Mheen, DE Grobbee, MG Marmot. Employment grade differences in cause specific mortality. Findings from the first Whitehall Study. *J Epidemiol Community Health* (Accepted for publication)

CTM van Rossum, M Shipley, H Hemingway, DE Grobeee, JP Mackenbach, MG Marmot. Seasonality in cause specific mortality. Are there high-risk groups? 25-year follow-up of civil servants from the first Whitehall Study. (Submitted)

Chapter 4

CTM van Rossum, H van de Mheen, JCM Witteman, JP Mackenbach, DE Grobbee. Socioeconomic status and aortic atherosclerosis in Dutch elderly people. The Rotterdam Study. (Submitted)

CTM van Rossum, H van de Mheen, MMB Breteler, DE Grobbee, JP Mackenbach. Socioeconomic differences in stroke among Dutch elderly women? The Rotterdam Study. *Stroke* 1999;30:357-62.

CTM van Rossum, H van de Mheen, JP Mackenbach, DE Grobbee. Income and prevalence, incidence and case-fatality of myocardial infarction among elderly men. The Rotterdam Study. (Submitted)

CTM van Rossum, H van de Mheen, JCM Witteman, DE Grobbee, JP Mackenbach. Education and nutrient intake in Dutch elderly people. The Rotterdam Study. (Submitted)

CTM van Rossum, H van de Mheen, JCM Witteman, A Hofman, JP Mackenbach, DE Grobbee. Prevalence, treatment and control of hypertension and sociodemographic factors among Dutch elderly people. The Rotterdam Study. (Submitted)

Other publication

J Seidell, CTM van Rossum. Obesitas en erfelijkheid: dik door een genetisch foutje? *Voeding Nu* 1998;1:21-23.

A Ott, CTM van Rossum, F van Harskamp, H van de Mheen, A Hofman, MMB Breteler. Education and the incidence of dementia in a large population-based study. The Rotterdam Study. *Neurology* 1999;52:663-6.

Dankwoord

Het schrijven van een proefschrift is net als het spelen van een kaartspel: je weet van tevoren niet hoe de kaarten geschud zijn, wie er allemaal mee gaan spelen, of je veel geluk hebt, hoe lang het gaat duren, en welke strategie je moet volgen. De leukste spellen speel je natuurlijk niet in je uppie. Ik ben dan ook blij dat ik de totstandkoming van dit proefschrift niet in mijn eentje heb gedaan, maar dat vele mensen hebben 'meegespeeld' of toegekeken. Via deze (onpersoonlijke) weg wil ik iedereen hiervoor ontzettend bedanken.

Allereerst natuurlijk mijn begeleiders, twee heren en een vrouw: Rick, Johan en Dike. Ik denk dat ik in een bevoorrechte positie was dat ik door drie personen werd begeleid. Door jullie verschillende achtergronden en persoonlijkheden hebben jullie mij verschillende aspecten van de epidemiologie bijgebracht. Dike, met name jouw persoonlijke en praktische benadering; Johan, jouw zorgvuldigheid in het doen van onderzoek; en Rick, jouw doelgerichtheid heb ik zeer gewaardeerd.

Heel veel dank ben ik verschuldigd aan alle mensen die ervoor gezorgd hebben dat ik de kaarten in handen kreeg: het hele ERGO-team, vanaf het allereerste begin tot nu. Hierbij denk ik aan de 'principal investigators', met name Bert Hofman, de coördinatoren, de secretariële ondersteuning, de computermannen, de data-managers, de onderzoeksmedewerkers, en alle collega-onderzoekers die er samen voor gezorgd hebben dat ERGO draaide. Daarnaast had ik zonder de bereidwilligheid van de deelnemers van het onderzoek en van hun huisartsen, helemaal niets kunnen doen. Dank u wel!

De medekaarters van de HVZ-club, onder leiding van Rick en later Jacqueline, en de GLOBE-club, onder leiding van Johan, hebben mij bijgespijkerd op het gebied van hart- en vaatziekten en de SEGV. Hartelijk dank hiervoor. Jullie hebben mij 'gemeind'! Jacqueline, bedankt voor de inhoudelijke discussies.

Het Centrum voor Verouderingsvraagstukken van de Erasmus Universiteit dank ik voor het groot enthousiasme wat ze in de multidisciplinaire aanpak van het verouderingsvraagstuk hebben gestoken.

Furthermore, I would like to thank Professor Michael Marmot, Martin Shipley, Gill Mein, Nicola Armstrong and Harry Hemingway of the department of Epidemiology and Public Health of the University College London. For me it was an honour and pleasure to work with you and due to your hospitality I had really a great time in London.

Voor de ideale entourage hebben mijn kamer(s)genoten gezorgd: Bettina, Carl, en Do en Anske, Irene(s), Maarten en Marianne. Jullie waren een enthousiaste supporter, maar vaker nog een goede coach. Jullie hebben er altijd voor gezorgd dat ik mij thuis voelde op de afdeling. Dank jullie wel voor de gezelligheid; ik zal jullie missen. Het langst heb ik met Bettina op de kamer gezeten. Bedankt voor vier jaar vriendschap.

Een aantal personen heeft zeer veel bijgedragen tot de afwerking van dit boekje. Ingrid bedankt voor het opkalefateren van mijn 'Engels'. Saskia en Marianne, enkele weken te herkennen aan het meesjouwen van het manuscript, wil ik ontzettend bedanken voor het gedetaileerd lezen van het manuscript. Tenslotte dank ik mijn 'broertje' Sjon voor de creatieve 'final touch'.

Er zijn teveel collega's bij MGZ en EPIB om allemaal afzonderlijk te bedanken. Elske en Caroline, bedankt dat ik altijd even een verdiepinkje lager kon binnenlopen voor de gezellige babbels. Ik kijk ook met veel plezier terug op 'de trekpleister-diners' met onder andere Iris, Jan-Cees, Liesbeth, Nicole, Raan, en Sandra, die voor de nodige ontspanning zorgden tijdens de laatste loodjes. Door jullie ben ik het koken bijna helemaal verleerd.

Een promovenda is niets zonder haar paranimfen. Elske en Marianne, ik ben blij dat ik er de 28ste niet alleen voor sta. Ik hoop dat jullie me dan net zoveel steun kunnen geven als de afgelopen jaren.

Als ik even afleiding nodig had buiten mijn werk kon ik die gelukkig altijd vinden bij mijn vrienden en familie. Jullie wil ik bedanken voor de noodzakelijke ontspanning en de belangstelling voor mijn onderzoek. Pap en Mam, ik ben trots op jullie! Dankzij de bagage, door jullie meegegeven, ben ik nu bijna gepromoveerd.

Ik hoop dat ik nu niemand vergeten ben. Misschien kan ik voor de mensen die ik onterecht niet noem, de joker inzetten?

Tot slot: lieve Marcel, ik hou van je!

Curriculum vitae

Caroline van Rossum werd op 28 juli 1968 in Woerden geboren. In 1986 haalde zij het VWO-diploma aan de Rijksscholengemeenschap 'F.A. Minkema' te Woerden. In datzelfde jaar begon zij aan de Haagse Hogeschool de opleiding Voeding en Diëtetiek. Tijdens deze opleiding heeft ze stage gelopen in het Leyenburg ziekenhuis te Den Haag en het Universitair Ziekenhuis te Gent, en werd een afstudeerproject uitgevoerd bij de GGD te Zoetermeer. Zij haalde het diploma in 1990 en begon daarna met de studie Voeding van de Mens aan de Landbouwuniversiteit te Wageningen. Zij deed doctoraalonderzoeken bij de vakgroep Gezondheidsleer, bij de vakgroep Marktkunde en Marktonderzoek en bij het Nutritional Institute te Bogor, Indonesië, in samenwerking met de vakgroep Humane Voeding. In 1993 studeerde zij cum laude af. Vervolgens heeft zij bij Solvay Duphar te Weesp gewerkt als data-manager voor klinisch onderzoek. Daarna begon zij als Assistent in Opleiding bij het Instituut Maatschappelijke Gezondheidszorg en het Instituut Epidemiologie & Biostatistiek van de Erasmus Universiteit Rotterdam. Hier werkte zij aan het onderzoek dat in dit proefschrift staat beschreven (onder supervisie van prof. dr. D.E. Grobbee en prof. dr. J.P. Mackenbach). Een gedeelte van het in dit proefschrift beschreven onderzoek werd uitgevoerd aan de University College London, Department of Epidemiology and Public Health (onder supervisie van prof. M.G. Marmot, MD). In 1996 ontving zij de Master of Science Degree in Epidemiology van het 'Netherlands Institute of Health Sciences'. Sinds september 1998 is zij als post-doc verbonden aan het Rijksinstituut voor Volksgezondheid en Milieu te Bilthoven waar zij onderzoek verricht naar de oorzaken van gewichtstoename.