NINA HAAPANEN-NIEMI

Associations of Smoking, Alcohol Consumption and Physical Activity with Health and Health Care Utilization

A Prospective Follow-up of Middle-aged and Elderly Men and Women

University of Tampere
Tampere 2000

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ACADEMIC DISSERTATION

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■

ACADEMIC DISSERTATION

To be presented, with the permission of
the Faculty of Medicine of the University of Tampere,
for public discussion in the auditorium of
Finn-Medi, Lenkkeilijänkatu 6, Tampere
on 15th April, 2000, at 12 o'clock.

University of Tampere
Tampere 2000

To my mother
and father

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LIST OF ORIGINAL PUBLICATIONS

This dissertation is based on the following original publications, which are referred to by their Roman numerals in the text.

I Haapanen N, Miilunpalo S, Pasanen M, Oja P, Vuori I (1997): Agreement between questionnaire data and medical records of chronic diseases in middle-aged and elderly Finnish men and women. Am J Epidemiol 145:762-769.

II Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M (1997): Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. Int J Epidemiol 26:739-747.

III Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M (1996): Characteristics of leisure time physical activity associated with decreased risk of premature all-cause and cardiovascular disease mortality in middle-aged men. Am J Epidemiol 143:870-880.

IV Haapanen-Niemi N, Miilunpalo S, Vuori I, Pasanen M, Oja P (1999): The impact of smoking, alcohol consumption, and physical activity on use of hospital services. Am J Public Health 89:691-698.

ABBREVIATIONS

BMI	=	body mass index
CHD	=	coronary heart disease
CI	=	confidence interval
COI	=	cost of illness
CVD	=	cardiovascular disease
LTPA	=	leisure-time physical activity
NIDDM	=	non-insulin dependent diabetes
QALY	=	quality adjusted life years
US	=	United States

1 INTRODUCTION

Increasing epidemiological evidence demonstrates that smoking, excessive alcohol consumption and physical inactivity are notable risk factors for several chronic diseases and mortality. According to recent estimates in the United States (US), the living habits in question, in the order of importance smoking, diet and activity patterns and alcohol, belong to the most prominent contributors to mortality (McGinnis and Foege 1993). As part of a strike-back public health policy, measures have been proposed to reduce the prevalence of poor living habits and thereby improve functioning, prevent suffering from premature morbidity and prolong survival of the population (e.g., Wood et al. 1998). Several studies support this view by showing that a large proportion of premature coronary heart disease (CHD) and stroke deaths, for example, has been avoided during the last few decades due to decreases in smoking and other coronary risk factors (Vartiainen et al. 1994b, 1995, Jousilahti et al. 1995, Hunink et al. 1997).

The findings on the relation between healthy living habits, favorable biological factors and the decreased risk of premature morbidity and mortality has led to the commonly accepted idea that prevention is a means of counteracting the continuously increasing health care expenditures typical nowadays for several countries (e.g., Fries et al. 1993). The pressure for cost-containment strategies is compounded by the probability of an increase in the demand for, and costs of, health services because of the increasing number of elderly people during the next few decades (Fries et al. 1993), and, for example, the rapid introduction of new, more expensive medical technology. In Finland there were 758 214 residents 65 years of age or older in 1998, but it has been estimated that the number will grow to 1 348 502 by the year 2030 (Statistics Finland 1998).

The commonly used slogan “An ounce of prevention is worth a pound of cure” (Sisk 1993) is sometimes misleadingly used to highlight the role of economics to attain savings in health care costs (e.g., Elkan 1992). From an economic point of view, prevention is an investment in health whereby the investor has to sacrifice something today to gain benefit tomorrow (Jönsson 1985, Weinstein 1990a). That is, the production of health involves the use of scarce resources that could have been used for other purposes (Cohen and Henderson 1988).

Within economic theory the role of prevention can be considered under normative or positive approaches (Boadway and Bruce 1989). The former approach (e.g., different forms of economic evaluation) concentrates on the question of how things ought to be. The normative approach is constructed on some notion of "good" and, furthermore, how this "good" should be distributed among the population. The positive approach is interested in how choices are made, and how the economy works and explains the phenomena important to the economy (e.g., economic models of health behavior).

The aim of this study was to add information on the role of selected living habits related to public health policy. Therefore, the purpose was to assess the effects and consequences related to smoking, alcohol consumption and physical activity in both health and economic terms. In more detail, it was targeted to study the association of the living habits in question with morbidity and mortality and, furthermore, to investigate whether the supposed health effects also influence the utilization of health services.

2 REVIEW OF THE LITERATURE

2.1 Health effects of smoking, alcohol consumption and physical activity – an epidemiological review

There is overwhelming evidence indicating short- and long-term adverse health effects in association with smoking, excessive alcohol consumption and physical inactivity (Hennekens 1998). In the following literature review the evidence obtained from epidemiological follow-up studies is described with emphasis on the major diseases associated with each of the selected living habits. Even though the three selected living habits have been herein separately considered, it is worth noting that they are evidently associated with each other (Miilunpalo et al. 1984, Pearson et al. 1987, Tuomilehto et al. 1987, Willett et al. 1987, Salonen et al. 1988, Middleton Fillmore et al. 1998a). Thereby the effect of several poor habits together on the risk of CHD, for example, is greater than the sum of the single risk factors (Paffenbarger et al. 1978).

2.1.1 Smoking and health

During recent decades the overall prevalence of smoking of the Finnish population has decreased. Despite the decline from 34% in the beginning of the 1980's to 30% in 1998, smoking is still common among Finnish men aged 15-64 years, especially among people with a low socioeconomic status (Helakorpi et al. 1998). It is also worth noting that, contrary to the trend for men, the prevalence of smoking has increased among Finnish women (Vartiainen et al. 1994a). In the beginning of the 1980's, 17% of the female population smoked, while in 1998 the proportion of female daily smokers had increased to 20% (Helakorpi et al. 1998).

Despite some health "benefits", for example, perceived temporary relaxation and lower relative risk for weight gain, especially in comparison with past smokers but also with never smokers (Williamson et al. 1991, Haapanen et al. 1997, Coakley et al. 1998), smoking is associated with many adverse health effects that lead to a decrease in well-being. The first evidence of the relationship between smoking and the increased risk of lung cancer was reported in 1950 (Peto et al. 1994). Since 1964 when the US Surgeon General identified smoking as the single most important cause of preventable mortality

(USPHS 1964), extensive research has assessed the disability, morbidity, and premature mortality attributable to tobacco use.

During the last 50 years both active smoking and passive smoking have been found to be major preventable causes of death not only from cancer, but also from cardiovascular disease (CVD) (Bartecchi et al. 1994, Rich-Edwards et al. 1995, Wood et al. 1998, Iribarren et al. 1999) and respiratory disease (USDHHS 1992, Bartecchi et al. 1994, Doll et al. 1994b, Peto et al. 1994). Furthermore, smoking is known to be associated with certain types of injury, including burns, poisoning and suicides (USDHHS 1992, Doll et al. 1994b, Leistikow et al. 1998), as well as with the sudden infant death syndrome (Anderson and Cook 1997), short gestation and low birth weight (USDHHS 1992).

Overall mortality

In developed countries alone, smoking is currently responsible for about 2 million deaths a year, about half of which are deaths in middle age (Peto et al. 1994). According to one estimate concerning the US population, smoking contributes to 19% of the deaths associated with non-genetic risk factors (McGinnis and Foege 1993).

Prospective epidemiological studies have consistently indicated that smokers experience a higher overall mortality relative to non-smokers (Rogot and Murray 1980, Kuller et al. 1991, Tverdal et al. 1993, Doll et al. 1994b, Yuan et al. 1996). According to a 40-year follow-up study carried out among male British doctors, the overall mortality was approximately twice as great for continuing cigarette smokers as for lifelong non-smokers throughout middle and early old age (Doll et al. 1994b).

In some calculations it has been estimated that smoking reduces the life expectancy of a 20-year-old person by 4.3 years (Manning et al. 1991). Similarly, among British male physicians a substantial decrease in life expectancy has been estimated. For cigarette smokers, the age at which half of the men had died was 8 years less than for non-smokers, while for heavy cigarette smokers it was 10 years less than for non-smokers (Doll et al. 1994b). It is worth to noting, however, that those who stopped smoking before middle age subsequently avoided almost totally the excess risk that they would have otherwise had (Doll et al. 1994b).

Cardiovascular diseases

It has been well documented that cigarette smoking substantially increases the risk of CVD, including stroke, sudden death, heart attack, peripheral vascular disease, and aortic aneurysm (USDHHS 1992, Bartecchi et al. 1994, Doll et al. 1994b). Recent reviews show also a relation between passive smoking and heart disease (e.g., Bartecchi et al. 1994, Glantz and Parmley 1995, Kawachi et al. 1997, Howard et al. 1998, He et al. 1999). Current epidemiological evidence indicates a significant dose-response effect in relation to passive exposure and suggests that non-smokers living with smokers have a 20% to 30% increase in the risk of death from ischemic heart disease or myocardial infarction (Glantz and Parmley 1991, Steenland 1992, Bartecchi et al. 1994, Glantz and Parmley 1995, Law et al. 1997, He et al. 1999).

CVD, of which CHD is the most common form, are the major causes of death in adults in their middle years and older in most European countries (Wood et al. 1998). Despite the decreasing trend of CHD mortality in Finland, as well as in several other western societies (e.g., Salomaa et al. 1992, McGovern et al. 1996, Hunink et al. 1997), 29% of all deaths in 1996 in a Finnish male population aged 35 years or more was related to CHD, while the corresponding proportion for women was 25% (Statistics Finland 1999). According to recent calculations for the population attributable risk for Finland, based on relative risk estimates and the prevalence of smoking among the middle-aged and elderly male population, from 10% to 33% of deaths from CHD could theoretically be delayed if all male smokers would stop smoking (Haapanen-Niemi et al. 1999). In the United States as many as 30% of all CHD deaths each year are attributable to cigarette smoking (Ockene and Houston Miller 1997), the risk being strongly dose-related (Rich-Edwards et al. 1995). The relative risk of ischemic heart disease for male and female smokers is about twice that of never smokers with a somewhat higher risk for the young and a lower risk for the elderly (USDHHS 1992, Ockene and Houston Miller 1997, Hennekens 1998).

There is also strong evidence that cigarette smoking increases the risk of stroke. The risk of cerebrovascular disease among smokers is 1.5 to 3 times that observed for non-smokers (Shinton and Beevers 1989, Bartecchi et al. 1994). Current knowledge indicates considerable differences in the relative risks for the subtypes of stroke, however (Colditz et al. 1988, Robbins et al. 1994). In a meta-analysis the variation of relative risks has been

shown as follows: 1.9 for cerebral infarction, 0.7 for cerebral hemorrhage, and 2.9 for subarachnoid hemorrhage (Shinton and Beevers 1989).

Several prospective investigations have demonstrated a substantial decrease in CHD and ischemic stroke mortality for former smokers in comparison with continuing smokers (e.g., Abbott et al. 1986). This risk begins to decline within a matter of months and falls to the level of the risk among nonsmokers within 2 to 14 years after smoking cessation regardless of the amount smoked, the duration of the habit or the age at cessation (Dobson et al. 1991, Kawachi et al. 1994, Rich-Edwards et al. 1995). Investigations have demonstrated that, even among persons with diagnosed CHD experience, the risk of reinfarction, sudden cardiac death and total mortality can be reduced as much as 50% if these persons quit smoking after the initial infarction (Ockene and Houston Miller 1997).

Cancers

Smoking is associated with an increased risk of cancers, including cancer of the mouth, pharynx, larynx, esophagus, bladder, pancreas and stomach cancers (Kuller et al. 1991, Bartecchi et al. 1994, Doll et al. 1994b, Dreyer et al. 1997a, Trédaniel et al. 1997). It has been estimated that smoking accounts for approximately 30% of all deaths from cancer (Doll and Peto 1981) and about 90% of lung cancer cases (Doll and Peto 1976, Peto et al. 1994, Bartecchi et al. 1994, Dreyer et al. 1997a). The risk of death from lung cancer has been estimated to be 10- to 30-fold among smokers, depending on the number of cigarettes and the duration of smoking, compared with that of non-smokers (Rogot and Murray 1980, USDHHS 1992, Tverdal et al. 1993, Doll et al. 1994b, Dreyer et al. 1997a). The accumulated evidence on lung cancer and environmental tobacco smoke, in turn, shows that the excess risk of lung cancer is about 20-40% for non-smokers who live with a smoker (Hirayama 1981, Fielding and Phenow 1988, Cardenas et al. 1997, Hackshaw et al. 1997).

Respiratory diseases, chronic obstructive pulmonary disease

Smoking causes a major part of the deaths from respiratory diseases, mainly due to pneumonia, influenza, chronic obstructive pulmonary disease, bronchitis and emphysema (USDHHS 1992, Bartecchi et al. 1994, Doll et al. 1994b). In a study carried out among male British doctors during a 40-year follow-up, chronic obstructive pulmonary disease showed a relation almost as strong as that of lung cancer (Doll et al. 1994b). According to a report of the US Department of Health and Human Services (USDHHS 1992) the relative risk of death from this disease is about 10-fold among both male and female smokers when compared with never smokers. In some studies the relative risk for asthma mortality has also been found to be more than double for those who had ever been smokers compared with never smokers (Doll et al. 1994b). Environmental smoking also has clear adverse health effects on respiratory diseases, for example, in the form of lower pulmonary function among non-smokers with asthma.

2.1.2 Alcohol consumption and health

During the 1980s the alcohol consumption of the Finnish adult population slowly increased, until the beginning of the 1990s (Helakorpi et al. 1998, STAKES 1997). According to the annual survey carried out by the National Public Health Institute, in 1998 40% of the men reported drinking 8 or more alcoholic beverages a week, while 25% of the women consumed 5 or more such beverages a week (Helakorpi et al. 1998). As for the officially registered and unregistered overall amount of pure alcohol consumed in 1996, it was 8.8 liters of absolute alcohol per inhabitant (STAKES 1997).

Alcohol has been commonly consumed throughout time because of its perceived benefits as a social lubricant and for relaxation, mood alteration, and sensory pleasure. Despite temporary benefits, the adverse health consequences associated with the long-term consumption of large amounts of alcohol are numerous. Excess alcohol consumption can cause, among other things, cirrhosis of the liver, pancreatitis, gastritis, hypertension, cardiomyopathy, dysrhythmia, hemorrhagic stroke, degenerative nervous system conditions, and a variety of cancers (Friedman and Klatsky 1993, Holman et al. 1996, Dreyer et al. 1997b, Thun et al. 1997).

Overall mortality

It has been estimated that, in 1990, alcohol caused 5% of all the preventable deaths in the United States (McGinnis and Foege 1993). In accordance, it has been estimated that for a person 20 years of age heavy drinking (i.e., two or more reported drinks a day) reduces life expectancy by 1.55 years (Manning et al. 1991). Another US study suggests that moderate drinking increases time until death from any cause by about 3%, whereas heavy drinking reduces time until death by 2% (Coate 1993).

In epidemiological follow-up studies the relation between alcohol consumption and total mortality has usually been found to be either J-shaped (Poikolainen 1995, Holman et al. 1996, Camargo et al. 1997a, Middleton Fillmore et al. 1998b, Hart et al. 1999) or U-shaped (Shaper et al. 1988, Klatsky et al. 1992, Doll et al. 1994a, Grønbæk et al. 1994, Fuchs et al. 1995, Duffy 1995, Thun et al. 1997). According to a recent meta-analysis, based on the pooled results of 14 cohort studies, 1.0-1.9 standard drinks per day for men and 0-0.9 drinks per day for women reduced all-cause mortality by 12% to 16% relative to that of abstainers (Holman et al. 1996). This finding supports the view that women are more sensitive to the effects of alcohol, and, respectively, the disadvantageous effects are increased by smaller amounts of alcohol among women than among men (Beaglehole and Jackson 1992, Holman et al. 1996).

Cardiovascular diseases

A large body of evidence suggests that low-to-moderate (i.e. 1 to 3 drinks a day) alcohol consumption provides protection against CVD (Shaper et al. 1988, Thun et al. 1997), especially against CHD, among both sexes (Stampfer et al. 1988, Rimm et al. 1991, Beaglehole and Jackson 1992, Maclure 1993, Rich-Edwards et al. 1995, Klatsky 1996, Camargo et al. 1997b). The estimated reduction in the risk of myocardial infarction associated with the mild-to-moderate consumption of alcohol is from 25% to 45% (Manson et al. 1992a). In Finland it has been estimated that, among men aged 30-69 years, approximately 12-14% of observed CHD deaths could theoretically be prevented if all men were light-to-moderate drinkers (Mäkelä et al. 1997). The reduction of CHD, as well as that of overall mortality, appears to be independent of the type of beverage consumed, and therefore alcohol itself, rather than other components of the drinks, is responsible for the

observed effects (Manson et al. 1992a, Poikolainen 1995, Klatsky 1996, Rimm et al. 1996).

In contrast to the protective effect of low-to-moderate alcohol consumption, heavy use of alcohol increases the risk of death from CVD. It may lead to cardiomyopathy, hemorrhagic stroke, cardiac arrhythmias and hypertension (Klatsky 1996, MacMahon 1987, Witteman et al. 1990, Beaglehole and Jackson 1992, Hart et al. 1999). A recent meta-analysis indicates U-shaped dose-response relationships for hypertension among women but arguably J-shaped relationships among men (Holman et al. 1996). Similarly, the relationship between alcohol consumption and stroke has been found to be J- or U-shaped (Beaglehole et al 1992, Holman et al. 1996), depending on whether ischemic and hemorrrhagic strokes are considered separately or combined (Stampfer et al. 1988, Camargo 1989, Hansagi et al. 1995).

Cancers

Excess alcohol consumption has been shown to be a cause for cancer of the mouth, pharynx, larynx, esophagus, and liver, as well as for fetal damage (Friedman and Klatsky 1993, Holman et al. 1996, Dreyer et al. 1997a, Thun et al. 1997). The combination of smoking and alcohol use accounts for about three-fourths of all oral and pharyngeal cancers (Bartecchi et al. 1994). In recent studies the evidence on the relation between high alcohol consumption and an increased risk of breast cancer has been strengthened as well (Rosenberg et al. 1993, Longnecker 1994, Fuchs et al. 1995, Holman et al. 1996, Thun et al. 1997, Smith-Warner et al. 1998). It has been estimated that about 2% of all cancers among men and 1% among women in the Nordic countries would be preventable if alcohol drinking were eliminated (Dreyer et al. 1997b).

Injuries and accidents

Several studies indicate that excessive alcohol consumption is associated with an increase in the number of injuries and accidents. It has been shown that alcohol plays a role, especially in combination with smoking, in the etiology of fire and burn injuries and deaths (Howland and Hingson 1987). It has also been well documented that traffic-related accidents (Honkanen et al. 1980) and trauma resulting from falls, fires, swimming, boating, and violence are linked to a high level of drinking (Honkanen et al. 1983, Cherpitel 1993,

1995). In the United States it has been estimated that alcohol is involved in a substantial proportion of injuries, with the percentages ranging from 3% to 50% of fatal traffic accidents (Treno and Holder 1997).

In a 13-year follow-up of British male doctors it was shown that, among those who drank alcohol regularly, there was a progressive increase in risk from alcohol-augmented causes that were injuries and poisonings, cirrhosis of the liver, upper cancers and alcoholic psychosis and dependence (Doll et al. 1994a). Similarly, in a recent 9-year follow-up study carried out in the United States, mortality from injuries and other external causes was 30% higher among men who drank 4 or more drinks a day than among non-drinkers, while no such association was found for women (Thun et al. 1997).

2.1.3 Physical activity and health

In general, physical activity has been defined as "any bodily movement produced by the contraction of skeletal muscles that increases energy expenditure above the basal level" (Caspersen et al. 1985, USDHHS 1996). Physical activity is also closely related to, but distinct from, exercise and physical fitness. Exercise is usually defined as a subset of physical activity that is "planned, structured, repetitive, and purposive bodily movement in order to improve or maintain one or more components of physical fitness". Physical fitness, in turn, is defined as "a set of attributes that people have or achieve that relates to the ability to perform physical activity" (Caspersen et al. 1985, USDHHS 1996). The focus of this review is on the major health effects associated with leisure-time physical activity (LTPA) revealed by epidemiological follow-up studies.

As evidence has increased on the health effects associated with moderate-to-high physical activity, recommendations for the public have been targeted. Until the beginning of the 1990's physical activity recommendations generally focused on 20 to 60 minutes of cardiorespiratory endurance, and they specified sustained periods of moderate-to-vigorous physical activity involving large muscle groups 3 or more times a week in order to increase and maintain physical fitness (USDHHS 1996). According to annual Finnish population surveys, the prevalence of LTPA among the Finnish adult population has slightly increased during recent decades (Helakorpi et al. 1998). Nevertheless in 1998, about 70% of the men and women between the ages of 15 and 64 years reported 3 or fewer bouts of weekly brisk

physical activity with a duration of at least 30 minutes (Helakorpi et al. 1998). Comparably, in the United States more than 60% of adults are not regularly active, and 25% of the adult population is not at all active (USDHHS 1996).

Several health benefits are associated with regular physical activity, and it is therefore preferable for all age groups. The positive health effects of regular physical activity include such issues as increased longevity, a lower risk for CVD and metabolic diseases, and an improved ability to maintain and regulate weight, mental health and quality of life (USDHHS 1996). There is also evidence that regular physical activity is associated with a decreased risk of colon cancer (Blair et al. 1992, USDHHS 1996, Colditz et al. 1997). Further research on the possible association between physical activity and breast (Friedenreich et al. 1998, Gammon et al. 1998) and prostate (USDHHS 1996) cancers is also recommended.

Overall mortality

In the United States it has been estimated that diet and physical inactivity cause altogether 14% of all the preventable deaths (McGinnis and Foege 1993). In accordance, it has been assessed that physical inactivity reduces life expectancy by 1 to more than 2 years (Paffenbarger et al. 1986, Manning et al. 1991).

The association between regular physical activity and the risk of overall mortality is well documented, especially for men (e.g., Paffenbarger et al. 1986, Leon et al. 1987, Lindsted et al. 1991), but during recent years increasingly also for women (Kaplan et al. 1996, Lissner et al. 1996, Kushi et al. 1997). There is strong evidence that those with moderate-to-high levels of physical activity have a lower mortality risk than those with sedentary habits (USDHHS 1996). The current evidence indicates that, compared with people who are the most active, sedentary people experience between a 1.2-fold and a 2-fold increased risk of dying (Salonen et al. 1982, Paffenbarger et al. 1986, Leon et al. 1987, Slattery et al. 1989, Paffenbarger 1993, Lissner et al. 1996, USDHHS 1996, Kujala et al. 1998, Wannamethee et al. 1998). In terms of population attributable risk it has been estimated that 16% of the overall deaths would be preventable if all the US men were physically active (≥ 2000 kcal per week); this estimate is comparable with that made for smoking (Paffenbarger et al. 1986).

Cardiovascular diseases

The major evidence, generally based on studies with male subjects (Morris et al. 1980, Garcia-Palmieri et al. 1982, Pekkanen et al. 1987, Donahue et al. 1988, Leon and Connett 1991, Lindsted et al. 1991, Eaton et al. 1995, Hedblad et al. 1997, Wannamethee et al. 1998), indicates that a low level of physical activity increases the risk of CVD in general and CHD especially (USDHHS 1996). Although the studies carried out before the 1980's were mainly concerned with occupational activity (e.g., Morris et al. 1953, Paffenbarger and Hale 1975) rather than the leisure-time activity commonly used thereafter, the direction of the association has been found to be relatively consistent in all the studies carried out during the past few decades (USDHHS 1996). Thus far a strong dose-response relationship has been demonstrated which indicates that the benefit derived from physical activity occurs at moderate levels of physical activity and increases with higher levels (Lakka et al. 1994, Hardman 1996, USDHHS 1996, Folsom et al. 1997, Manson et al. 1999). A number of studies have found that those physically inactive have approximately double the risk of CHD than that of physically active people (Powell et al. 1987, Berlin and Colditz 1990, USDHHS 1996). Compared with men, however, the relation between LTPA and CVD or CHD risk remained unclear among women until a number of studies indicated no association between the level of LTPA and CVD or CHD death (e.g., Powell et al. 1987, Sesso et al. 1999). In their recent study Manson et al. (1999) found a strong, graded inverse association between total physical activity level and the intensity of walking and the risk of CHD events among a large female population, however.

According to recent estimations for the population attributable risk for middle-aged Finnish men, from 22% to 39% of deaths from CHD could theoretically be delayed if all middle-aged men were physically active (at least 30 minutes of low-to-moderate physical activity at least 4 times a week) (Haapanen-Niemi et al. 1999). For some other populations sedentary activity-related estimates of population attributable risk have varied from 14% to 35% for deaths from CHD (Paffenbarger et al. 1993, Powell and Blair 1994, Eaton et al. 1995). These estimates, carried out in different countries, indicate that, as a CVD risk factor, physical inactivity is a public health problem comparable to cigarette smoking and such biological risk factors as high blood pressure and high cholesterol levels (Powell et al. 1987).

Physical activity prevents or delays the development of high blood pressure among normotensive subjects (e.g., Paffenbarger et al. 1983, 1991, Fagard and Tipton 1994, Hardman 1996, Pereira et al. 1999), but it also reduces blood pressure among people with hypertension (Arroll and Beaglehole 1992, ACSM 1993). Several epidemiological studies and randomized controlled trials indicate that aerobic physical activity will elicit a 5-10 mmHg average reduction in both systolic and diastolic blood pressure in persons with mild essential hypertension (Arroll and Beaglehole 1992, ACSM 1993, Kelley and McClellan 1994). On the basis of epidemiological cohort studies, it has been estimated that the least active persons have a 30% greater risk of developing hypertension than their most active counterparts (USDHHS 1996).

Some studies have suggested that an increased level of LTPA has a protective effect against stroke (Håheim et al. 1993, Lindenstrøm et al. 1993, Wannamethee and Shaper 1992, Gillum et al. 1996, Lee and Paffenbarger 1998), while others report no such association (Salonen et al. 1982). In their study, Abbott et al. (1994) distinguished 4 stroke subtypes and found that the preventive role of physical activity varied by stroke form. The inconclusive role of physical activity may be associated with the different pathophysiologies so that physical activity may not affect hemorrhagic and nonhemorrhagic stroke in the same way (Blair et al. 1992, USDHHS 1996).

Despite the numerous health benefits, people with compromised coronary circulation can develop angina or acute myocardial infarction during vigorous activity (USDHHS 1996). Arrhythmia can be precipitated by a combination of exertion and underlying heart disease, and can sometimes lead to sudden death (Thompson 1996). Compared with sedentary people, who begin suddenly exercising vigorously, persons exercising regularly have a lower risk of exercise-related sudden death, although even this group has a transient elevation of risk during and immediately after vigorous activity. The absolute incidence of sudden cardiac death in relation vigorous activity is low for the general population, however (Vuori et al. 1978, Thompson 1996).

Diabetes

All the few conducted prospective follow-up studies support an inverse association between physical activity and the risk for non-insulin dependent diabetes (NIDDM or type II-diabetes) (Helmrich et al. 1991, Manson et al. 1991, Manson et al. 1992b, Burchfiel et al. 1995, Perry et al. 1995, Lynch et al. 1996, Baan et al. 1999). In prospective epidemiological studies the potential reduction in the risk of this disease in association with regular moderate or vigorous physical activity versus a sedentary life-style has varied from 30% to 50% (Manson and Spelsberg 1994).

Current evidence indicates a dose-response relationship between the level of physical activity and the risk of NIDDM. A 14-year prospective follow-up study of US male university alumni demonstrated that every 500 kilocalorie increment in LTPA per week was associated with a 6% reduction in diabetes risk after adjustment for age, body mass index (BMI) and other potential confounding factors (Helmrich et al. 1991). In a 5-year prospective study of male physicians aged 40-84 years, the age- and BMI-adjusted relative risk of NIDDM decreased with an increasing frequency of physical activity, 0.78 for once weekly, 0.68 for 2 to 4 times per week and 0.71 for 5 or more times per week, when compared with men having physical activity less than once a week (Manson et al. 1992a).

Physical activity and diet have been found to be the most effective means of controlling NIDDM in persons who have a mild form of the disease and who are not on medication. However, excessive physical activity can cause detrimental effects such as worsening hyperglycemia and ketosis from poorly controlled diabetes or hypoglycemia either during vigorous physical activity or, more commonly, some hours after prolonged physical activity (USDHHS 1996).

Musculoskeletal health including injuries and accidents

The role of regular physical activity in promoting musculoskeletal health varies depending on the diagnosis of interest. According to current knowledge, physical activity and, especially, that of a weight-bearing type of activity prevents osteoporosis, which is characterized by decreased bone mass and structural deterioration of bone tissue that leads to bone fragility and increased susceptibility to fractures (USDHHS 1996, Kannus 1999).

Osteoarthritis, the most common form of arthritis, is characterized by both the degeneration of cartilage and new growth of bone around the joint. Regular physical activity is necessary to maintain and improve joint mobility, muscular strength and endurance, and it appears to be beneficial for controlling symptoms among people with osteoarthritis. There is no evidence that physical activity itself causes osteoarthritis, but injuries sustained during competitive sports have been shown to increase the risk of developing this disease (USDHHS 1996).

The epidemiological data regarding the association between LTPA and back pain are few, and the results are conflicting. There is some evidence that vigorous and straining activity is associated with increased back injury rates, while in other studies exercise and physical activity have been widely prescribed as a treatment for low-back pain (Biering-Sørensen et al. 1994).

The drawback associated with physical activity appears to be numerous musculoskeletal injuries, since acute stress from sudden forceful movement can cause strain, tears and fractures. Despite the importance of this relationship, the number of population-based longitudinal studies about the association of LTPA and sports with injuries remained minimal until recent decades (Kraus and Conroy 1984, Pate and Macera 1994).

During the last few decades the number of sports injuries has increased rapidly in the Finnish adult population aged 15-75 years from the 210 000 reported in 1980 (Heiskanen and Koskela 1994) to the 267 000 reported in 1997 (Heiskanen and Aromaa 1998). Recently, the total number of sports injuries comprised the largest cause of injuries (28%) in Finland (Heiskanen and Aromaa 1998). Sports injuries have remained more common among men (70%) than among women (30%) and among the young than among the elderly (Heiskanen and Koskela 1994, Heiskanen and Aromaa 1998). During the 1990's the total number of sports injuries has been highest for jogging, which is also one of the most popular forms of activity among Finnish adults. In 1993 the incidence rate for sports injury from jogging was 203/10 000 participants, while the highest injury rates were found for soccer (755/10 000 participants), volley ball (504/10 000 participants), ice hockey and ice ball (500/10 000 participants) and squash (361/10 000 participants). One of the lowest injury rates has been found for cross-country skiing and swimming, for

example, which have traditionally been some of the most popular forms of physical activity in Finland (Heiskanen and Koskela 1994).

The findings concerning sports injuries in Finland are congruent with the results of a recent US study in which the frequency of injuries associated with 5 commonly performed, moderately intense activities (walking for exercise, gardening and yard work, weight lifting, aerobic dance and outdoor cycling) was studied (Powell et al. 1998). The injury rates were lowest for walking and highest for weight lifting. During walking and gardening men and women were equally likely to be injured, but younger people from 18 to 44 years of age were more likely to be injured than older people aged 45 years or more. Large numbers of people were injured, but the injury rates were low because the participation rates were high. Most of the injuries were minor, but injuries can reduce participation in these otherwise beneficial activities.

2.1.4 Summary of the health effects of living habits

Epidemiological follow-up studies consistently show that smoking, excess alcohol consumption and physical inactivity are the major single causes of all-cause and disease-specific morbidity and mortality. The accumulation of several poor living habits or biological risk factors increase the risk for premature morbidity and mortality even more than their additive effects do.

Despite the convincing body of health-related effects of several living habits, a number of questions remain to be answered. Most of the studies thus far have been carried out among men. Therefore there is an evident need for information about the health effects of living habits among women, including the most common causes of morbidity and mortality such as CVD. Furthermore, there are several living habit-related diseases that have seldom been studied longitudinally, even among both genders, for example, stroke, NIDDM and musculoskeletal diseases. In considering LTPA, further information about the dose-response relations is needed in terms of the relative contributions of the frequency, intensity, duration and type of physical activity to specific health effects. Similarly, comparable information about living-habit-related health effects, including independent and joint effects, is needed for both international and national purposes so that effective health policies can be established for populations.

2.2 Economic consequences of smoking, alcohol consumption and physical activity

2.2.1 Alternative approaches

The economic consequences of smoking, alcohol consumption and physical activity have been investigated in several ways, each designed to answer different questions. These approaches include cost-of-illness (COI) methodology, different forms of economic evaluation within the cost-benefit framework, epidemiological framework, economic models of health behavior and a number of other applied methods. In the following text the main features of the first 4 methodologies are briefly described as an introduction to the review of the economic aspects related to the living habits in question.

2.2.1.1 Cost-of-illness methodology

COI methodology is a commonly used form that assesses the economic burden of poor living habits, through disease burden, on society. COI studies, based on the human capital approach (described in more detail later in this section), can be undertaken according to 1 of 2 approaches. The prevalence approach estimates the total costs of a disease resulting from a poor habit in a given year regardless of the time of onset of the disease (Drummond 1992, Ament and Evers 1993). The incidence approach estimates the living-habit-related costs of cases, first diagnosed in a given year, over the person's lifetime (Drummond 1992). When incidence-based costs are estimated, information is required on the likely course of a disease and its duration, including survival rates by time since onset, used medical care, and cost during the length of the disease (Hodgson and Meiners 1982). COI studies also cover the economic consequences of production losses caused by sickness, disablement and death (Hodgson and Meiners 1982, Godfrey and Powell 1987, Shiell et al. 1987, Ament and Evers 1993).

There are several shortcomings related to COI estimates, however. Many living-habit-related illnesses are chronic, and the latency period between the initiation of smoking, for example, and the onset of illness may be long. As a consequence, prevalence-based cost estimates reflect the consequences of historical trends of a habit, and these

estimates may differ among countries at different times. Accordingly, prevalence-based cost estimates cannot be used to predict the impact of living-habit-related policies, except after long periods (USDHHS 1992).

Lifetime or incidence-based COI estimates are preferred over prevalence-based estimates for measuring the costs of changes in and trends affecting, the incidence of disease. The incidence-based approach suffers from the limitations of transferability between countries. Furthermore, the approach does not directly address intangible costs and externalities. Similarly, it values mortality and morbidity by measuring forgone earnings rather than willingness-to-pay. Moreover, even for economically advanced countries the incidence-based approach is limited by the lack of adequate and comprehensive data (USDHHS 1992).

2.2.1.2 Cost-benefit thinking

It has been suggested that the preceding cost-based COI methodology has comprised the starting point for earlier forms of economic evaluation (Drummond 1992). Differing from COI methodology, however, the main purpose of different forms of economic evaluation is to assess not only the costs but also the benefits related to alternative actions.

In the context of public health policy the economic evaluation of different public health strategies or treatments can be made according to cost-benefit thinking, within which the following 3 variants have usually been separated: cost-benefit analysis, cost-effectiveness analysis and cost-utility analysis (Drummond 1980, Drummond et al. 1987, Farnham et al. 1996). A common feature for all these economic evaluation approaches is that they compare the resources consumed by a public health-related activity (costs) with the health improvement (benefits) created by an activity or strategy. The primary distinction between each technique is associated with the way in which benefits are assessed. This distinction reflects the fact that each technique is designed to answer different questions (Weinstein and Stason 1977).

Under the cost-benefit framework each of the subapproaches involves systematic identification, measurement and, where appropriate, valuation of all the relevant costs and benefits of the options (Banta and Luce 1983). In an economic evaluation, the costs and

benefits are closely related concepts (Drummond 1980). Costs stem from alternative uses of scarce resources. These opportunity costs of resource use are defined as the benefit that would be derived from using the resource in its best alternative way (Warner and Luce 1982, Garber et al. 1996, Weinstein et al. 1996). The benefits, in turn, do not only include the benefits derived from being healthy per se, but also the benefits derived from patients or clients being able to return to work and hence add to national production.

Traditionally the literature concerning cost-benefit thinking has classified the costs (i.e., the resources) consumed by public health activities, first, into direct costs such as the costs of tests, outpatient physician visits, hospital care, counseling and drugs and, second, into indirect costs, including the costs of lost production. The third category of costs has comprised the intangible costs. This last category can represent the monetary value of pain, grief and suffering of the patient and family, for example (Drummond 1980, Torrance 1986, Drummond et al. 1987, Weinstein 1990b, Luce et al. 1996). The existing empirical evidence shows, however, that the classification into direct, indirect and intangible costs and benefits has not been consistent across the studies and therefore has sometimes caused confusion (Drummond et al. 1997).

The question of how to handle future medical costs which occur when a preventive or curative intervention extends life, has arisen frequently but remained unresolved. In his theoretically-based review Meltzer (1997) concludes that the criteria of cost-effectiveness or cost-utility analysis for the allocation of medical expenditures are strictly consistent with a model of lifetime utility maximization only if they account for effects on future related and unrelated medical expenditures, as well as consumption and earnings. In practice, however, it is not common to include these costs in medical cost-effectiveness or cost-utility analysis, partially since there has been theoretical disagreement as to whether they should be included. Changes in the levels of future expenditures conditional on survival may be neglected in most instances, but should be included if they are reflected in the approach used to assess the quality of life, are too large to be considered changes taking place at the margin, or if there are reasons to expect these allocations to deviate significantly from efficient ones.

According to a number of empirical studies Melzer (1997) suggests that the magnitude of unrelated medical expenditures, consumption, and earnings may be large

enough to substantially alter the cost-effectiveness or cost-utility of common medical or preventive interventions, especially where an intervention has greater effects on life expectancy than on quality-adjusted life expectancy. This statement implies that existing cost-effectiveness and cost-utility analyses are generally biased to favor interventions that extend the length of life over interventions that improve its quality. Overall, it was suggested that all future costs should be routinely included in cost-effectiveness or cost-utility analysis.

In considerations of benefits in cost-benefit analyses health and welfare improvement caused by public health-related activity are expressed in monetary terms. In cost-effectiveness analyses the health-related benefits can be measured in natural units, as prevented cases, disability days or hospital days and lives saved or life-years gained, for example. In cost-utility analyses one can measure the value of health improvement in utility units, nowadays more commonly with quality adjusted life years (QALY) (Drummond 1980, Torrance 1986, Drummond et al. 1987).

Thus far the studies including indirect consequences have generally applied the human capital approach in valuating production losses (Zweifel and Breyer 1997). Human capital valuation is based on the assumption that earnings reflect productivity (Hodgson and Meiners 1982, Shiell et al. 1987). There are several critical components included in the human capital approach, and these components make the use of this approach ethically questionable (Jones-Lee 1976, Zweifel and Breyer 1997). As human capital thinking relies on earnings, the approach tends to give greater weight to working-age men than to women or the young, for example (Hodgson and Meiners 1982, Ament and Evers 1993). Another point of human capital criticism concentrates on the discrimination against and exclusion of non-market activities such as domestic work. The approach also ignores the non-financial costs of pain, suffering and grief, which are often associated with illness. From the point of view of economic theory the main criticism has concentrated on the fact that the approach is not based on an individual person's valuation of benefits as assumed under welfare economics, but, indeed, a third party view is taken about people's worth to society in terms of their productive potential. Another criticism has centered on the use of rates of pay as a measure of value in the imperfection-characterized labor markets (Shiell et al. 1987). The human capital method reflects reality only if the sick or deceased worker is not replaced. During the periods of high unemployment, for example, it is likely that these

conditions do not apply in practice, and, consequently, the sick or deceased person will be replaced with some other persons at little cost (Shiell et al. 1987, Ament and Evers 1993, Koopmanschap et al. 1995).

As a response to the frequent criticism attached to the human capital approach and the practical problems related to willingness-to-pay valuation method, the friction cost method for estimating indirect costs of disease has been under development since the beginning of the 1990's. In the friction cost method the basic idea is that the amount of production loss due to disease depends on the time-span needed by organizations to restore production to its initial level (Koopmanschap et al. 1992). It is assumed that, if unemployment, registered or hidden, is beyond the level of frictional unemployment, sick employees can be replaced after a period necessary for adaptation. Frictional unemployment is an inevitable part of unemployment, since filling vacancies takes time and some qualitative discrepancies between labor demand and supply always prevail. Production losses are assumed to be confined to the "friction" period needed to replace a sick worker (Koopmanschap et al. 1995).

Despite some improvements over the human capital approach, the practical applications of the friction cost method have thus far been few. Thus there are still numerous uncertainties associated with the consideration of indirect costs. Therefore, this study has concentrated on direct economic consequences, and, when no cost data have been available, the results concerning the utilization of living habit-related health care have been reported instead of costs. Due to the lack of follow-up studies, also some selected estimations based on cross-sectional study designs have been taken into account.

2.2.1.3 Epidemiological framework

Within the epidemiological framework different living habits, among other things, can be seen as exposures for a number of outcomes. The benefits of preventive actions, such as LTPA, can be assessed as the decreased morbidity and mortality rates, for example. It can be further considered, by epidemiological methods, whether the positive effects on morbidity and mortality are reflected also as decreased use of health services. Similarly, the role of poor living habits, such as smoking, can be considered in relation to morbidity and mortality and, furthermore, to find out if the increased risk for lung cancer, for example, is reflected as a increased use (and costs) of health services.

2.2.1.4 Economic models of health behavior

The basis of economic models of health behavior is resting on the decisions and choices of individual persons. During recent decades several economic models of health behavior have been constructed. The main emphasis of these models has usually been on health, which has been explained through the use of health services, living habits and sociodemographic factors, among other things. In the following presentation 3 well-known economic models of health behavior have been introduced.

In their paper *Evans and Stoddart* (1990) proposed, within a *macroeconomic framework,* a model that represented a wide range of relationships among the determinants of population health. Using current literature, the authors built up the model component by component, beginning from the simplest stage and taking the relationship between health and health care under consideration. The model was extended step by step, including also biological and behavioral determinants. It was concluded that life-style has a large effect on health. Living habits, including diet, physical activity and smoking, for example, were also founded to be the factors most readily portrayed as under the control of the individual.

The authors concluded that the model should accommodate distinctions among disease, as defined and treated by the health care system, health and function, as perceived and experienced by individuals, and well-being, a still broader concept to which health is an important, but not the only, contributor. It should build a framework to permit and encourage a more subtle and more complex consideration of both behavioral and biological

responses to social and physical environments. It should also recognize and foster explicit identification of the economic trade-offs involved in the allocation of scarce resources to health care instead of other activities of value to individuals and societies, activities which may themselves contribute to health and well-being.

Another model of the demand for health, presented originally by *Grossman* (1972a,b), has often been claimed to be one of the basics of the *microeconomic modeling* of health behavior (Van Doorslaer 1987, Gerdtham and Johannesson 1999). This theory is characterized by aspects derived from the household production theory (Becker 1965) and neoclassical human capital-based investment models (Maynard 1983).

At the heart of the household production theory is the assumption that households are producers as well as consumers; they produce commodities by combining inputs of goods and time according to the cost-minimization rules of the traditional theory of the firm (Becker 1965). Commodities are produced in quantities determined by maximizing a utility function of the commodity set subject to prices and a constraint on resources. Resources are measured by what is called full income, which is the sum of money income and that forgone or "lost" by the use of time and goods to obtain utility, while commodity prices are measured by the sum of the costs of their goods and time inputs.

In applying the human capital-based investment model, Grossman (1972a,b) supposed that a person inherits an initial stock of health which depreciates over time but which can be augmented by investment. He also assumed that, in accordance with one's preferences, a person rationally aims to maximize his or her health over the life span since good health is a durable commodity that yields both utility and healthy time to the individual. A person is supposed to aim the utility by allocating lifetime resources and time between the production of commodities that yield utility directly and investment in health, which while not yielding utility directly, increases the individual's stock of health. This in turn yields both consumption and investment benefits to a person. As an investment commodity, health status determines the total amount of time available for market and non-market activities. Therefore, an increase in the stock of health reduces the time lost from these activities, and the monetary value of this reduction is an index of the return on an investment in health.

Referring to the concepts of "consumption" and "investment" commodities Grossman (1972a,b) considered separately pure health-related consumption and investment submodels. In considering the investment submodel, Grossman (1972a,b) suggested that direct inputs into the production of gross investments in the stock of health include such items as own time, health improving (e.g., exercise) or worsening (e.g., smoking) living habits. Referring to the interrelationships between the demand for health and health services he (1972a,b) supposed that consumers do not demand health services per se but rather because of good health. Thereby utilization of health services was expected to be an essential investment input for good health. The production function depends also on certain sociodemographic factors, such as age and the level of education and wage.

Overall Grossman's work (1972a,b) offers a plausible abstraction from the real life investment in health choices that a person faces (Forster 1997). Similarly, the predictions of the models are themselves interesting, and the approach has been increasingly applied in several studies in the area of health economics. The issues considered under the Grossman-type theory have included both theoretically (Cropper 1977, Muurinen 1982, Wagstaff 1986b, Becker and Murphy 1988, Dardanoni and Wagstaff 1990) and empirically (e.g. Wagstaff 1986a, Van Doorslaer 1987, Sintonen and Tuominen 1989, Mullahy and Portney 1990, Häkkinen 1991, Koivukangas 1993, Pohlmeier and Ulrich 1995, Forster 1997, Gerdtham and Johannesson 1999) emphasized investigations about the aspects related to the demand for health and health care utilization.

A microeconomic model of health behavior, including aspects similar to Grossman's, (1972a,b) has been introduced by *Jones* (1994, Jones et al. 1999) who has concentrated on identifying the determinants of quitting smoking, along with the subjects' knowledge of the health risks of smoking. In these specifications a static health production framework has been combined with the demand for health knowledge. In the models it has been assumed that people maximize their utility from the consumption of goods and services, subject to a budget constraint and a health production function.

In the static household production tradition, health was treated as a fundamental choice variable, and the demands for medical care and living habits, among other things, were seen as derived demands for health inputs. Along with beneficial and harmful activities, health was also affected by a set of characteristics that were intended to capture

the individual's genetic, environmental and social identity. In practice, future health is inherently uncertain, and medical diagnoses, the efficacy of treatment and prognosis, are also uncertain. Therefore, the individual does not choose the realizations, but only the conditioning variables, in the random process that determines their health. Observed health reflects a combination of preferences, opportunities, and uncertainty, and may be subject to heterogeneity bias. As such, it was suggested that there is a good case for treating health as an endogenous variable in empirical analyses. In the empirical models the decision to quit smoking was treated as a choice under uncertainty that incorporated health, medical advice, addiction, and social interaction. Overall, the results showed a clear role for addiction, social interaction and current health status (Jones 1994) as determinants of success in quitting smoking.

2.2.2 Smoking and economic consequences

In the following review, mainly the direct economic costs related to the use of outpatient physician services, hospital care and medication have been included. The consideration of indirect effects was excluded due to the number of uncertainties related to the production lost estimates.

During the past few decades numerous studies have been conducted on the economic consequences of smoking. The role of smoking as an economic burden to society has varied from study to study depending on the time period considered and the methodology used (Godfrey and Powell 1987). In several studies smoking has been shown to increase the economic burden of society (e.g., Choi and Pak 1996), while others have argued that smokers "pay in their way" and therefore cause minor or no costs to society (Leu and Schaub 1984, Manning et al. 1989, Lippiatt 1990, Pekurinen 1992).

Numerous studies about smoking and health care use have come from cross-sectional data, yet they have often been based on self-report of the utilization of health care (Pekurinen 1989) or on non-individual-based data (e.g., Rice et al. 1986, Phillips et al. 1992). As an exception, a recent US study was targeted to compare the use of outpatient and hospital services prospectively for 2440 persistent smokers and 244 biochemically verified quitters, all of whom were participants in 2 independent randomized trials of smoking cessation intervention. The findings showed that, in both trials, continuing

smokers experienced a 7% to 15% increase in outpatient visits and a 30% to 45% increase in hospital admissions over the 5 to 6 years of follow-up compared with the baseline year. Among the quitters, all the health care use rates significantly increased during the year in which they quit; thereafter, the rates declined progressively. By the fourth year after quitting, all the use rates of the quitters were lower than those of the smokers. The increase in hospitalization during the year of quitting was more often a cause rather than a consequence of successful smoking cessation (Wagner et al. 1995). No cost estimates were demonstrated in this study, however.

Several smoking-related COI studies, usually based on the prevalence approach (USDHHS 1992), have indicated a large economic burden on the health care system (e.g. Luce and Schweitzer 1978, Forbes and Thompson 1983, Collishaw and Myers 1984, Rice et al. 1986, Phillips et al. 1992, USDHHS 1992, Fox et al. 1995, Miller et al. 1998a, Single et al. 1998). According to current evidence, smoking is estimated to account for 8% to 12% of health care expenditures in the United States, for example (Luce and Schweitzer 1978, Hinds 1986, Miller et al. 1998a). In Finland it was estimated in 1987 that some 3.9% of medication expenditures were smoking related, while 2.3-3.0% of general hospital-care-related costs and 3.6-3.8% of outpatient physician-visit-related costs were due to smoking (Pekurinen 1992).

Some of the incidence-based COI studies have indicated remarkable medical care costs attributable to smoking (Oster et al. 1984, Manning et al. 1989, Hodgson 1992). One of the highest estimates has been presented by Hodgson (1992), who analyzed data on the use and costs of medical care and on mortality for specific age groups of the US population to generate profiles of lifetime health care costs beginning at 17 years of age. In this study it was concluded that smoking-related medical care increase with the amount smoked among men and women so that the lifetime medical costs of male heavy smokers are 47% higher than those of never smokers when discounted at 3%.

In his review, however, Ellemann-Jensen (1991), for example, has argued that a numerous earlier prevalence- and incidence-based COI studies (e.g. Oster et al. 1984) are methodologically erroneous and yield cost estimates that are too high. According to Ellemann-Jensen (1991) these COI analyses do not offer any welfare economic basis for policy.

Some other authors argue that, even though smokers do incur greater health care costs at any given age, compared with nonsmokers, reduced smoking rates may not necessarily translate into reduced lifetime medical expenditures (Barendregt et al. 1997). This is possible since smoking tends to kill smokers at an earlier age, whereby non-smokers have more years during which to use health services. In other words, non-smokers have more years of old age, years often plagued by chronic illness and large medical bills (Warner 1987, Elixhauser 1990). In considering some single studies, a Swiss study suggested that non-smokers live longer and use medical services heavily during the last year of their lives. As a result, the total health care costs of non-smokers to society were estimated to be higher than for smokers (Leu and Schaub 1983). In a subsequent report, discounting with a variety of rates the authors again found that lifetime medical expenditures were lower for smokers than for non-smokers (Leu and Schaub 1984). A conclusion close to the preceding one has been derived also in a US investigation in which no consistent increase in remaining lifetime hospital days was found for ever smokers. In fact, male ever smokers older than 44 years and female ever smokers older than 38 years could be expected to have fewer lifetime hospital days than never smokers (Weinkam et al. 1987).

In a recent Dutch report it was concluded that health care costs for smokers at a given age were as much as 40% higher than those for non-smokers, but in a population in which no one smoked the costs were 7% higher for men and 4% higher for women than the costs in the mixed population of smokers and non-smokers (Barendregt et al. 1997). If all smokers quit, health care costs would be lower at first, but after 15 years they would become higher than at present. In the long term, complete smoking cessation would produce a net increase in health care costs (Barendregt et al. 1997).

Some of the studies have assessed the role of smoking through economic evaluation. Close to that of the cost-benefit approach, the effect of an anti-smoking campaign on health care costs was tested in a British simulation model (Haycox 1994). It was concluded that an assumed permanent 5% effective anti-smoking program would lead to a 0.15 % increase in total life years and would produce numerous other health gains. Furthermore, the model predicted that over a lifetime total hospital expenditures would increase, while expenditures for primary health care could be expected to fall as a result of

smoking cessation. Overall, such an anti-smoking program was expected to lead to a minor overall reduction in health care costs (Haycox 1994).

Although smoking cessation may not produce savings, or it does it in a short time period (Lightwood and Glantz 1997), it seems to be highly cost-effective when compared with other types of preventive intervention (Cummings et al. 1989). The results have been found especially cost-effective when targeted toward a particular population subgroup (Elixhauser 1990, Cromwell et al. 1997, Plans-Rubió 1998), but promising findings have also been found in some population-based studies (Tillgren et al. 1993). In a Swedish study that comprised a large population-based sample of 12 840 people and used smoking-cessation programs based on a national mass media strategy and an organizational strategy, the result was favorable cost-effectiveness estimates when compared with those of other preventive and treatment programs (Tillgren et al. 1993). This promising finding in a "quit and win" contest, regarded as a method for helping tobacco users quit, is in agreement with several "self-help" types of intervention. Despite this, however, the self-help quit-smoking interventions have often been reported to have numerous limitations, such as a short follow-up period or a lack of random assignment, which have restricted the generalization of the results (Elixhauser 1990).

2.2.3 Alcohol consumption and economic consequences

According to several COI studies the social costs of alcohol consumption, related especially to alcohol abuse, have been found to be high in several countries, including Finland (Salomaa 1993), the United States (Luce and Scweitzer 1978, Rice et al. 1991), Canada (Adrian 1988, Single et al. 1998, Xie et al. 1998), Japan (Nakamura et al. 1993) and New Zealand (Devlin et al. 1997). In some COI studies alcohol-related social (Luce and Schweitzer 1978) or external costs (Manning et al. 1989) have been assessed to be even higher than those related to smoking. The COI studies that are typically prevalence-based calculations with secondary data sources indicate that alcohol-related social costs are heavily associated with the excess use and costs of health care, but also with social care and criminal justice costs, fire losses, traffic accidents and reduced labor productivity (Luce and Schweitzer 1978, Adrian 1988, Salomaa 1993, Devlin et al. 1997, Single et al. 1998). It has been suggested that alcohol use in any year may yield costs that are

equivalent to 2-5% of the national gross domestic product (Nakamura et al. 1993, Godfrey 1997).

In Finland alcohol-related costs increased from 1980 to 1990 faster than did the consumption of alcohol. It was estimated that, in 1990, the proportion of costs directly related to alcohol varied between FIM 2.8 and FIM 3.7 billion and the indirect costs ranged from FIM 9.9 to FIM 18.1 billion (Salomaa 1993). During the year, the alcohol-related taxes (FIM 8.9-10.4 billion) covered about 40-80% of the total amount of direct and indirect costs (Salomaa 1993). This finding agrees with the US finding according to which drinkers pay, through alcohol taxes, about half of the costs imposed on others (Manning et al. 1989). Similarly, in Japan, the total amount of alcohol-abuse-related costs have been estimated to be 3 times the national revenue from taxes on alcoholic beverages (Nakamura et al. 1993).

The number and costs of alcohol-related utilization of health services has been assessed to be high (Ashton 1984, Adams et al. 1993, Fox et al. 1995, Devlin et al. 1997). In a recent 20-year follow-up study among Swedish twins the proportion of hospital admissions attributable to high levels of alcohol consumption was 13% for men and 1% for women (Andreasson and Brandt 1997). In another study carried out in New Zealand, it was estimated that 2.7% of hospital costs were attributable to alcohol abuse (Devlin et al. 1997). In some calculations the alcohol-attributable costs associated with medical care have been estimated to be 7% of total health care costs (Nakamura et al. 1993). In Finland it has been estimated that, in 1990, health care costs formed the second largest alcohol-related direct cost category, with a proportion of 26% after general order and criminal costs (Salomaa 1993). Since the beginning of the 1990's the total number and incidence of alcohol-related hospital care periods have frequently increased (STAKES 1997). Similarly, it has been shown that the length of hospital admissions related to alcohol use, typical especially for men aged 30-59 years, are longer than average, and they therefore increase the costs related to hospital care (Sillanaukee et al. 1994).

In the United States it has been estimated that the health care costs of high alcohol users are 2 to 3 times those of the average user (Holder 1987). Most of this difference has been explained as being attributable to hospital care resulting from substantially higher inpatient days per person for alcoholics (Holder 1987). According to a recent US time-

series analysis carried out from 1950 to 1992, 22-26% of US community hospital admissions are alcohol-related (Muller 1996). A comparable analysis indicated that the per capita alcohol and tobacco expenditures contributed to approximately 28% of US community hospital admissions (Muller 1996). A population-based 8-year study among problem drinkers showed that these drinkers utilized injury-related medical care at a rate of 1.6 times that of the comparison group, and they had injury-related medical care costs which were 3 times as high (Blose and Holder 1991). While female problem drinkers had a lower overall level of injury-related care than males, their relative risk was somewhat higher (1.91 versus 1.54).

In 2 cross-sectional studies no or a weak association between the use of alcohol consumption and the utilization of health care services was found. In a cross-sectional population-based US study among participants aged 60 years or older, it was found that heavy alcohol consumption was even associated with fewer self-reported physician visits (Rice and Duncan 1995). Another cross-sectional study carried out among 82 430 US adult health maintenance organization (HMO) members showed that the heaviest drinkers (≥ 6 alcoholic beverages per day) had an increased number of total hospital days while the moderate users (0.25-2 alcoholic beverages per day) had a decreased number of hospital days compared with abstainers (Armstrong and Klatsky 1989). In this population of prepaid health-plan members the excess use of alcohol consumption was associated also with an increased number of hospital days related to accidents, poisonings and violence (Armstrong and Klatsky 1989). The use of any amount of alcohol consumption was associated with a decreased number of hospital days due to circulatory problems compared with abstainers, however. In accordance with this finding, in 2 other studies total alcohol drinking was inversely related to the risk of CHD hospitalization when no attention was paid to the total number of hospital days (Klatsky et al. 1986, 1997).

The alcohol-related estimates of the social costs and the findings from cross-sectional studies already presented have, however, little policy relevance when decisions about resource allocation have to be made. In other words, they do not identify the type of intervention in which investment produces the greatest increase in benefit at least cost (Maynard and Godfrey 1994). What little evaluation has been undertaken indicates that low-cost minimal intervention may be cost effective for the wider population of problem drinkers. Other, more intense types of intervention are likely to be cost effective only if

well targeted towards appropriate client groups (Tolley and Rowland 1991, Maynard and Godfrey 1994).

2.2.4 Physical activity and economic consequences

Thus far the economic consequences associated with physical activity have been studied relatively little. Furthermore, most of these studies have included more or less assumptions. Keeler et el. (1989) applied the previously described incidence-based COI approach and estimated the external lifetime costs for the hypothetical cohorts of sedentary and physically active men and women aged initially 20 years. Several observational studies were used to estimate the cost components. The authors concluded that, if sedentary persons were more active, they would live longer and reduce the costs they impose on others. The reduced costs would come from lower covered medical and work loss associated with an active life-style. The higher taxes paid by the active persons over their longer lifetimes more than offset the additional pension payments received by active people as a result of their increased life expectancy. Furthermore, according to the comparison calculations, the external costs of a sedentary life-style are almost double the external costs of smoking (Keeler et al. 1989, Manning et al. 1991).

In a British simulation model presented by Nicholl et al. (1994), morbidity risks associated with the level of physical activity were used to estimate the incidence of hospital admissions and mortality, and associated health care costs, which could be prevented if the whole population exercised. Literature on the incidence and costs of exercise-related morbidity and mortality was considered to derive estimates of both the costs to health and the health care resource implications of exercise in a total population. The results showed that, for younger adults (ages 15 to 44 years), the average annual medical care costs per person that might be incurred as a result of full participation in sports and exercise exceeded the costs that might have been avoided by the disease-prevention effects of exercise. For older adults (at least 45 years) the estimated costs avoided greatly outweighed the costs that would be incurred. These findings are close to the estimates derived in 2 cross-sectional Dutch surveys with the self-reported use of medical services. Exercise costs exceeded the benefits for younger adults, but the situation was reversed for older ones (Reijnen and Velthuijsen 1989, Stam et al. 1996). Overall, according to secondary data-based calculations, the health care costs of physically inactive

Dutch persons slightly exceeded the estimates for physically active ones (Reijnen and Velthuijsen 1989, Stam et al. 1996). Similarly, in a US cross-sectional study with men and women aged 22 to 99 years, increased physical activity was associated with fewer self-reported doctor visits due to any reason (Wetzler and Cruess 1985).

Most of the few studies assessing the cost-effectiveness of physical activity have included numerous assumptions because of the scarcity of adequate data. With the exception of one study (Jones and Eaton 1994), however, the investigations have implicated minor or no economic savings but have indicated some suggestions about the favorable cost-benefit or cost-effectiveness ratios (e.g., Hatziandreu et al. 1988, Munro et al. 1997, Stevens et al. 1998).

Hatziandreu et al. (1988) estimated the health and economic implications of exercise in preventing CHD among 2 hypothetical male cohorts 35 years of age, one with exercise (at least 2000 kcal/week) and the other without, for 30 years. Differences were observed in the number of CHD events, in life expectancy, and in the quality-adjusted life expectancy. Jogging was used as an example to calculate cost, injury rates, adherence, and the value of time spent. Both the direct and indirect costs associated with exercise, injuries and treating CHD were considered. The authors estimated that exercising regularly resulted in fewer CHD events and more QALYs gained over the 30-year study period. Under their base assumptions, which included both direct and indirect costs, such as time spent in exercise, discounted with the annual rate of 3%, exercise did not produce economic savings either in terms of direct or indirect costs. The cost per QALY gain of USD 11 313 (adjusted for 1985 dollars) was considered favorable when compared with other preventive or therapeutic types of intervention for CHD, however. An alternative model in which the hypothetical exercise program was targeted at the men who considered it to be enjoyable or at least neutral showed net economic savings in both direct and indirect costs.

In another study decision-analysis simulation was used to evaluate the cost-benefit relationship of walking to prevent CHD with the base of hypothetical cohorts of sedentary men and women aged 35 to 74 years. Under assumptions close to those of Hatziandreu et al. (1988), walking was economically beneficial for middle-aged and elderly men while, for women, no savings were estimated. The threshold of relative risk at which economic

benefit was found for walking in the total sample was estimated to be 1.7, while most adults enjoying to walk would benefit even at a lower relative risk (Jones and Eaton 1994).

As a consequence of the increased incidence of chronic diseases among the elderly and the increased rates of injuries related to physical activity among young subjects, it has been suggested that the greatest benefit for the least cost is likely to come from physical activity carried out by older rather than younger age groups (Nicholl et al. 1994). In a recent British study the cost-effectiveness of physical activity was estimated for the population over 65 years of age (Munro et al. 1997). The starting point of the study was participation twice a week in a publicly funded aerobic-style exercise program in the context of a large randomized trial of physical activity. Intervention-related cost and benefit items were based mainly on assumptions, and, finally, the estimates were generalized for a hypothesized population of 10 000 persons. The study concluded that a publicly funded program of moderate exercise for people over 65 years of age would prevent premature death, reduce inpatient episodes and would cost about GBP 330 (costs given at 1993-1994 prices) per life-year saved, with a mean expectation of life of 10 years after 65 years of age (Munro et al. 1997).

Yet another method used to reflect the economic consequences related to physical activity has been a risk approach. With this approach it does not make any difference how many outpatient physician visits or hospital days, for example one has had, however. According to this approach increased participation in physical activity or sports has been found to be associated with a decreased risk of hospitalization due to CVD (LaCroix et al. 1996, Kujala et al. 1996) and respiratory diseases (Kujala et al. 1996), but there is an increased risk of hospitalizations due to musculoskeletal diseases among middle-aged and elderly men (Kujala et al. 1996) and injuries from falls among young men (Malmivaara et al. 1993) within follow-up times varying on the average from 4.2 (LaCroix et al. 1996) to 21 (Kujala et al. 1996) years. According to a recent US study with a 12- to 16-year follow-up period, an increase in physical activity was associated with a decrease in the risk of hospitalization due to any reason among women aged 65 years and older, while no association was found in any other gender- or age-specific stratum (Miller et al. 1998b).

2.2.5 Summary of the economic consequences related to living habits

The results concerning the economic consequences of smoking, alcohol consumption and physical activity vary from study to study depending on the time period considered and the methodology used. In general, due to the shortage of actual, individual-based data derived from the general population, most of the current studies include a number of assumptions, especially in estimating the different indirect costs related to living habits. Similarly, relatively few studies with actual population-based longitudinal data have been conducted even on direct costs such as the utilization of health care services. As a consequence of the large variation in methodologies and assumptions, including those concerning costing methods and discounting rates, the conclusions about the economic consequences of smoking, for example, have been found to be controversial. According to some studies smoking imposes a large economic burden on health care systems or whole societies, while in other studies smokers have been found to use health care services less during their life-span than never smokers and to pay the share of the costs they impose on society. As a consequence, there is an evident need for population-based longitudinal studies that use observed data on exposures and outcomes and are thus able to provide reliable estimates of the economic consequences of various living habits.

2.3 Interpretation of cohort studies

Epidemiological studies are carried out to identify exposures (e.g., physical activity or smoking) that may affect the occurrence of a disease or other health-related outcome and to estimate quantitatively their effect. Errors are possible in almost any epidemiological study, however. Thus, when findings from epidemiological studies are interpreted, including the previous ones described in the section 2.1, it is essential to consider if the observed association between an exposure and an outcome may have been affected by errors in the design, conduct or analysis. Even if errors do not seem to be an obvious explanation for the observed effect, it is necessary to assess the likelihood that the observed association is a causal one. The following aspects should be addressed before it is concluded that the observed association between an exposure and an outcome is a true cause-effect relationship: (1) the possibility of systematic errors (bias) in the way subjects were selected and followed up or in the way information was obtained from the study subjects, for example, (2) the possible role of a confounder that was not measured or taken

into account in the analyses and (3) the possibility of chance (Gordis 1996, Rothman and Greenland 1998, dos Santos Silva 1999).

2.3.1 Selection and measurement bias

Bias tends to lead to an incorrect estimate of the effect of an exposure on the development of a disease or other outcome of interest. The observed estimate may be either above or below the true value, depending on the nature of the error. For simplicity, bias can be grouped into 2 major types: selection bias and measurement bias. Selection bias occurs when there is a difference between the characteristics of the subject selected for the study and the characteristics of those who were not (dos Santos Silva 1999). Measurement or information bias occurs when a measurement or classification of an outcome or exposure is not valid. This type of bias may occur when measurements do not measure correctly what they are supposed to measure. Errors in measurement may be introduced by the observer, study subject or the instruments used to make the measurements (dos Santos Silva 1999).

The ways of minimizing selection bias in cohort studies include decisions about the clear definition of a population, the inclusion and exclusion criteria and the minimization of refusals and losses to follow-up, for example. Similarly, decisions are needed about the similarity of the groups, except for the exposure status, and about the adequate follow-up time. The ways of minimizing measurement bias in cohort studies include decisions about the clear definition of exposures and outcomes with standard and valid criteria, the objectivity of the measurements used and confirmation about the information provided by the study subject against any existing records. In addition to identifying potential sources of bias in a particular study, their most likely direction and magnitude need to be estimated (dos Santos Silva 1999).

2.3.2 Confounding

Confounding occurs when a variable is associated with the exposure under study and it is also an independent risk factor for the outcome (Gordis 1996, Rothman and Greenland 1998). Confounding can be dealt with at the study design level (e.g. randomization, restriction, matching) or, after the relevant data have been collected, in the analysis (stratification and statistical modeling) (dos Santos Silva 1999).

2.3.3 Chance

The role of chance can be assessed by performing appropriate statistical significance tests and by calculating confidence intervals (CI). A statistical significance test for the effect of an exposure on an outcome yields the probability (p-value) that a result is as extreme as or more extreme than the one observed could have occurred by chance alone. In case this probability is very small, it is usual to declare that chance is an unlikely explanation for the observed association and consequently, that there is a statistically significant association between the exposure and outcome (Gardner and Altman 1989).

The value of *p* depends both on the magnitude of the association and on the sample size (Gardner and Altman 1989). It is therefore possible with a small number of subjects studied to obtain a p-value which is not statistically significant, despite the fact that the true population exposure effect is large. Conversely, with a large sample, small effects, which may be clinically and epidemiologically irrelevant, may easily achieve statistical significance. Therefore, confidence intervals are more informative than p-values because they provide a range of values for the exposure-outcome association, which is likely to include the true population effect. Overall, one should keep in mind that the statistical p-values and confidence intervals assess only the effects of sampling variation and cannot control for non-sampling errors such as confounding or bias in the design, conduct or analysis of a study.

Since one cannot be sure that the study was not affected by bias, confounding or chance, one has to consider the findings in the context of all available evidence. In his world-wide known paper and later adapted in a number of studies and papers (e.g., Paffenbarger 1988, Rothman and Greenland 1998) Bradford Hill (1965) named nine aspects (1) strength, (2) consistency, (3) specificity, (4) temporality, (5) dose-response relationship, (6) plausibility, (7) coherence, (8) experimental evidence and (9) analogy that need to considered when assessing whether an association is likely to be causal.

(1) Strength. The strength of the association is measured by the magnitude of the ratio or incidence rates. A strong association is more likely to be causal than weak because, if it were due to confounding or some other bias, the biased association would have to be even stronger and would therefore presumably be evident.

(2) Consistency. Consistency refers to the repeated observation of an association in different populations under different circumstances. If similar results have been found in different populations using different study designs, the association is more likely to be causal. However, a lack of consistency does not exclude a causal association, since different intensity levels and other conditions may reduce the impact of the exposure in certain studies.

(3) Specificity. The criterion of specificity requires that a cause leads to a single effect, rather than to multiple effects. If a particular exposure increases the risk of a certain disease or health-related outcome but not the risk of other diseases or outcomes, this provides evidence in favor of a cause-effect relationship. However, one-to-one relationships between exposure and outcome are rare, and a lack of specificity should not be used to refute a causal relationship.

(4) Temporality. Temporality refers to the necessity that the exposure precedes the outcome in time.

(5) Biological gradient. The biological gradient refers to the presence of a dose-response relationship between exposure and outcome. Further evidence of a causal relationship is provided if increasing levels of exposure are associated with increasing incidence of disease or other outcome.

(6) Plausibility. Plausibility refers to the biological plausibility of the hypothesis. The association is more likely to be causal if it is consistent with other biological knowledge (e.g., animal experiments, biological mechanisms). The criterion of plausibility is an important concern but may be difficult to judge. This may happen because the lack of plausibility may simply reflect s lack of scientific knowledge or the fact that human beings are biologically different from animals.

(7) Coherence. The term coherence implies that a cause-and-effect interpretation for an association does not conflict with what is known of the natural history and biology of the disease or other outcome.

(8) Experimental evidence. The criterion about the experimental evidence is seldom available for human populations.

(9) Analogy. Simple analogies can enhance the credibility that an association is causal.

According to Hill (1965) these nine conditions, later termed as “criteria”, should not be regarded as necessary conditions to establish causality. The only exception is the criterion of temporality – for an exposure to be a cause of a disease or other outcome, it clearly has to precede the outcome.

3 PURPOSE OF THE STUDY

The purpose of the present study was to assess, through epidemiological framework, the health effects and economic consequences related to smoking, alcohol consumption and leisure-time physical activity (LTPA) among middle-aged and elderly men and women. Based on the theoretical background presented earlier, the specific empirical aims of the study were:

1. To investigate the agreement between questionnaire data and medical records of selected chronic diseases among middle-aged and elderly men and women in order to ensure the relevant use of self-reported morbidity data (I).

2. To investigate the effect of LTPA on chronic metabolic disease-related morbidity and mortality among middle-aged and elderly men and women (II and III).

3. To investigate the effects of smoking, alcohol consumption and LTPA on the use and costs of hospital services, outpatient physician services and medication among middle-aged and elderly men and women (IV, appendix 1 and 2).

A model of the relationships investigated in the current study is presented in Figure 1.

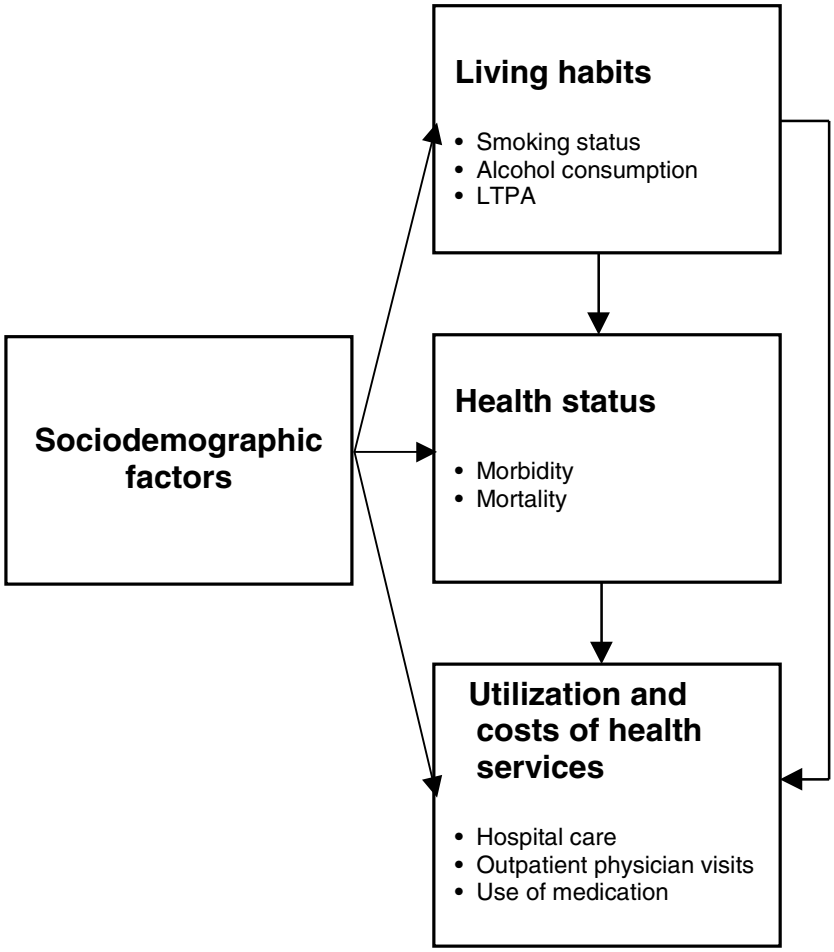

Figure 1. Relationships between the major components of the study

4 MATERIALS AND METHODS

4.1 Study subjects

A systematic and representative sample (n=6787) of residents between 19 and 63 years of age was drawn from the census data of a medium-sized industrial town (Kajaani) and two adjoining rural municipalities (Sotkamo and Suomussalmi) in northeastern Finland. The sample represented about 20% of the noninstitutionalized working-age population of the municipalities in the target area in 1980. A self-administered questionnaire was sent to the subjects at the beginning of 1980. The final response rate, after two reminders, was 77.5%, 81.2% for the women and 73.9% for the men. The response rate was lowest for the age group 19-29 years, 79.3% for the women and 71.3% for the men (Miilunpalo 1989). Thereafter, the 2564 men and 2695 women who answered the baseline questionnaire formed the cohort population (Figure 2).

In study I, the agreement between self-reported diseases in the questionnaire survey and data from medical records was assessed in a representative, random subsample of the original cohort in order to validate the relevant use of self-reported morbidity data in a subsequent step of the study. The sample consisted of 300 men and 300 women who were initially aged 35-63 years and who answered the follow-up questionnaire in 1990 and lived in the target municipalities during the year in question. There were 4 subjects with no information about medical records whereby the final sample comprised a total of 596 men and women.

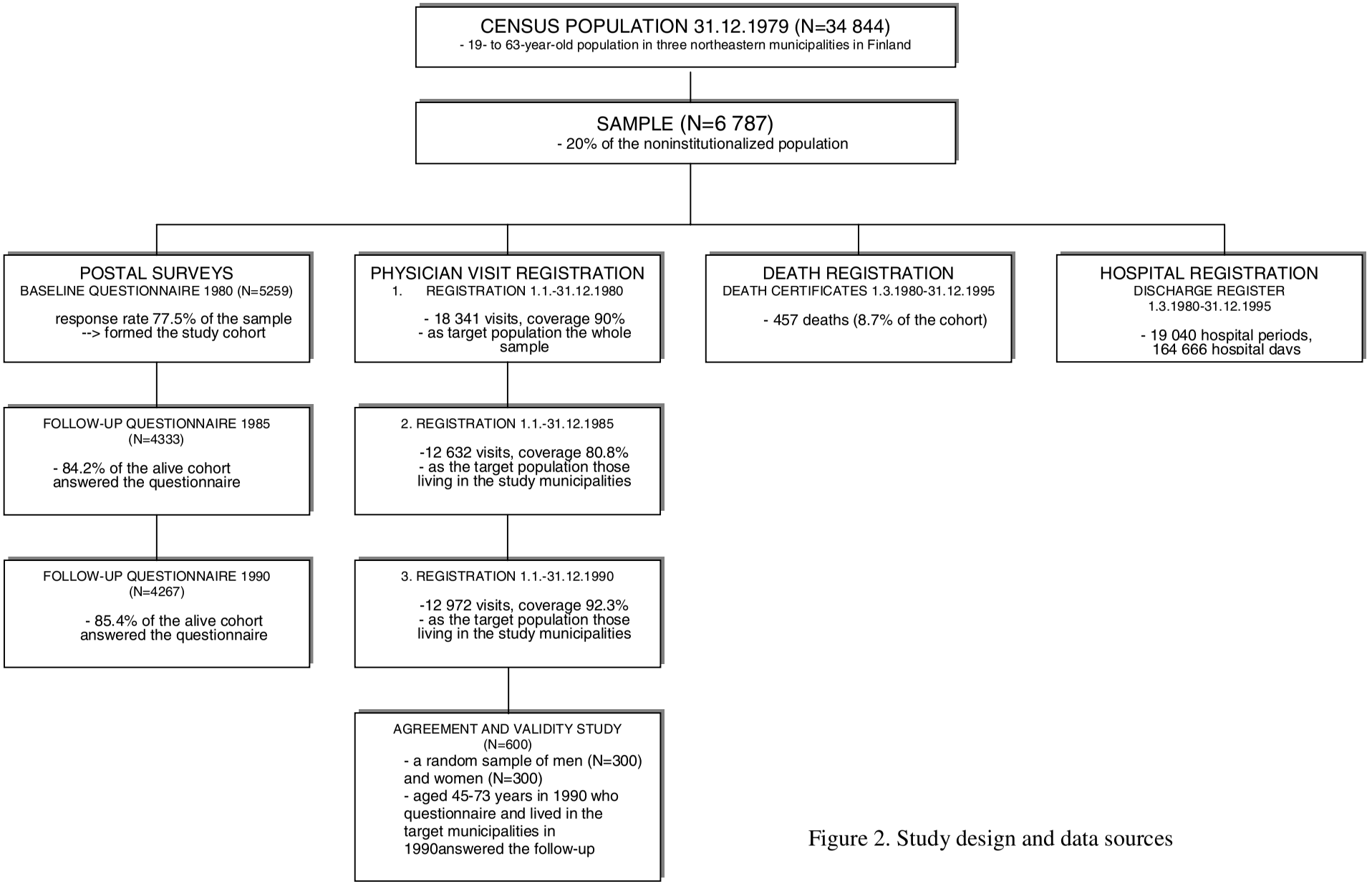

Figure 2. Study design and data sources

In study II, the association of the total amount and intensity of LTPA on the risk of CHD, hypertension and NIDDM was studied in a cohort of men and women aged initially 35-63 years. Of the initial 1340 men, from 1139 to 1182 had outcome information on the selected disease in 1985 or 1990 or both, and the corresponding numbers for the initial 1500 women were 1358 to 1363. As a means of reducing any bias regarding the analysis, those who reported the outcome disease in the first survey or reported being totally unable to participate in physical activity due to their health status and those failing to respond to 5 or more of the 13 questions concerning baseline physical activity were excluded from the analysis. Altogether, 865 men and 965 women aged 35-63 years were included in the CHD analysis. Similarly, 731 men and 796 women were included in the hypertension analysis, and 891 men and 973 women qualified for the analysis regarding diabetes.

In study III, the association between LTPA and the risk of death was analyzed for the men initially aged 35-63 years. As means of reducing any selective bias, all of the 1340 men who reported that they were totally unable to participate in physical activity because of their health status or had failed to respond to 5 or more of the 13 questions concerning baseline physical activity were excluded from the analysis. After the exclusions, 1072 men were included in the analysis.

In study IV, the association between smoking, alcohol consumption and LTPA and the use of hospital care was investigated among an initial cohort of 5259 men and women 19 to 63 years of age. The subjects with an unknown postal address in 1985 or 1990 were excluded from the analysis, whereby the total sample consisted of 2534 men and 2668 women. For the diagnosis-specific analysis, the respondents who reported diseases of the circulatory or respiratory system in the initial questionnaire were excluded from the analysis concerning these diseases. The respondents having registered outpatient visits for musculoskeletal problems in 1980 were excluded from the analysis concerning these diseases. Different exclusion criteria were used based on the findings of study I.

4.2 Data collection

4.2.1 Self-administered questionnaires

A self-administered questionnaire including structured questions on living habits and health behavior, health status, and sociodemographic background factors was sent to the subjects at the beginning of 1980. The final response rate, after 2 reminders, was 77.5% (n=5 259). Follow-up questionnaires requesting similar information were sent to the respondents 1, 5 and 10 years later. The response rates for these surveys were 88%, 84% and 85% of the alive cohort. The questionnaire-based measures used in the study have been described in more detail with frequencies in studies I-IV.

4.2.2 Death register

The mortality of the respondents in the baseline survey was monitored through national census data from Statistics Finland (previously called the Central Statistical Office of Finland) from 1 March 1980 through 31 December 1995. A total of 268 men and women initially aged 19-63 years died during the follow-up period of 10 years and 10 months (studies II and III) while 457 subjects died by the end of 1995. In the total cohort CVD was the most important cause of death among both the men (50%) and the women (52%).

4.2.3 Hospital discharge register

The use of hospital care among the subjects was determined between 1 March 1980 and 31 December 1995 from all public and private hospitals providing inpatient services in Finland. The hospital care data were obtained from the Finnish hospital discharge register. During the 16-year follow-up period the data included a total of 164 666 hospital days and 19 040 hospital admissions for the men and the women initially aged 19-63 years.

For hospital admissions Fin-DRG (diagnosis-related groups) adjusted cost weights based on the International Classification of Diseases, 9th revision, was used (appendix 2). The DRG system employs a grouping procedure that takes into account the patient's primary and secondary diagnoses, surgical procedures, age and mode of discharge. The

Fin-DRG patient classification system is a Finnish version of the HCFA (Health Care Financing Administration) DRG grouping method. With the method the 470 DRG groups were weighted accordingly to the actual average costs incurred by each episode. DRG-based costs have been available since 1987; therefore the associations of the considered living habits with the hospital care-related costs were considered from 1 January to 31 December 1995.

4.2.4 Outpatient physician visits

The use of outpatient physician services was studied for the complete calendar years in 1985 and 1990 among the men and women initially aged 35-63 years. This investigation covered all the 15 centers (municipal health centers, outpatient wards of the regional central hospital, private clinics and occupational health care units) providing outpatient services in the target municipalities. The outpatient contacts were recorded in co-operation with the local health authorities and care providers. The coverage of the data compilation was checked against statutory medical files kept by the care provider. When contact was recorded, the outpatient data were completed, when practically possible, with individual data from the archives of the statutory medical files.

The costs per outpatient physician visit in health centers and outpatient wards in a regional central hospital in 1985 and 1990 were derived from the annual statutory accounting reports kept by the administrative officials in each of these municipalities. The costs of the outpatient physician visits in private clinics were derived from the statistics kept by the Finnish Social Insurance Institution (1985, 1990), while, for occupational health care, the average cost of health center and private care were derived. All the outpatient physician visits were transformed into costs for the year 1995 with the use of the health care index towards the public sector.

4.2.5 Medical records

For publication I the medical record information was gathered from a random sample (n=600) of the living men and women initially aged 35-63 years. The accumulated information about the selected chronic diseases until 1 March 1990 and the latest information concerning medication in 1990 were gathered manually from the statutory medical files kept by the care provider from 3 local municipal health centers and from the central hospital in the study region.

The use of medication in 1990 was transformed into costs for the year 1995 by Pharmaca Fennica (Lääketietokeskus 1995). Altogether, 58% of the men and women had used at least some prescribed medication in 1990 with average costs of FIM 1940 for the men and FIM 1799 for the women.

4.3 Statistical methods

In study I, the medical record diagnosis for each chronic disease (yes or no) was cross-tabulated with that of the self-reported answer (yes or no) obtained from the questionnaire. The analysis of the agreement between the 2 methods was first based on the definite diagnoses and subsequently on both possible and definite diagnoses in the medical records, with the exception of hip and knee arthrosis, for which it was not possible to assess whether the diagnosis was possible or definite.

Kappa coefficients were calculated to determine the agreement between the self-administered questionnaire data and the medical records. In accordance with earlier recommendations (Landis and Koch 1977) a kappa value of less than 0.40 was considered poor-to-fair agreement, 0.41-0.60 was considered moderate agreement, 0.61-0.80 was considered substantial agreement, and 0.81-1.00 was considered almost perfect agreement. The validity of the self-administered questionnaire data, in comparison with the medical records obtained from the local municipal health centers and from the central hospital in the study region, was expressed in terms of sensitivity (true positives correctly identified/all true positives), specificity (true negatives correctly identified/all true negatives), positive predictive value (true positives correctly identified/all positives

identified by the questionnaire data), and negative predictive value (true negatives correctly identified/all negatives identified by the questionnaire data).

In study II, the morbidity rates per 1000 person-years of follow-up were computed for each of the categories of initially assessed LTPA and for the confounders included in the models. In study III corresponding computations were made for mortality. The morbidity and mortality rates were age-adjusted by the direct method using the total population as the standard. The age-specific observations were not reported due to the relatively small number of study subjects. The multivariate analysis for estimating the relative risks with respect to person-years was computed using the Cox proportional hazards model (Cox 1972) in Egret software. In study III, the association of specified activities of daily living and domestic chores that were the most strongly related to the risk of death was assessed with single-item measures of LTPA using log-linear models.

In study IV, initially 2 different models were used for the count data, namely, the Poisson and the negative binomial regression model, and compared with regard to fit with the hospital data. In accordance with the procedures of some recent studies (Häkkinen et al. 1996) a 2-part model with a logistic regression model and a zero-truncated Poisson or negative binomial model were also applied and their goodness-of-fit was compared with the afore-mentioned 1-part models. The aim of the 2-part modeling was first to explain in a logistic regression the dichotomy of having or not having hospital days in the total sample and then, by the zero-truncated model, to analyze the number of hospital days for those having at least 1 hospital day during the follow-up. The goodness-of-fit of all the models was compared by means of log-likelihood functions. Similar models were tested also for outpatient physician visits (appendix 1).

In the data the negative binomial model gave a clearly better fit than the Poisson model did. The distributions of the hospital days and outpatient physician visits were skewed and the variances were distinctly larger than the means, whereby the Poisson distribution did not fit the data. In a comparison between the 1-part and 2-part models the goodness-of-fit was consistently better in the ordinary 1-part models. Therefore, finally, only the negative binomial model was used with the total sample to assess the differences in the average number of hospital days per 100 person-years and the number of outpatient physician visits per year as an average of the years 1985 and 1990. For the analysis

concerning the use of hospital services, the individual follow-up times varied, however, because of deaths during the follow-up. Thereby this variation was taken into account by including the logarithmic of the follow-up years as a fixed intercept term with a regression coefficient equal to 1 in all the models. The goodness-of-fit of the models was compared by means of log-likelihood functions. Due to some extremely high numbers of hospital days for a few subjects, these outlying values were replaced by the second highest value in the data before the fitting of the models. The statistical modeling was done using LIMDEP software (Greene 1995).

The Fin-DRG-based costs weights per individual follow-up period were considered. When the costs of the use of the outpatient physician services were in question, the costs per year were considered, while for the use of medication, the costs were transformed cross-sectionally for 1990. In all the cost analyses, the Tobit regression model was used to assess the differences in costs according to the selected living habits (Greene 1993).

5 RESULTS

5.1 Validity of the questionnaire data (I)

In order to ensure the valid use of the self-reported morbidity data in a later step of the study, the agreement between self-reported diseases in a questionnaire survey and data from medical records was assessed (study I). There was a wide variation in agreement between the questionnaire data and the medical records, depending on the specific diagnosis. The agreement was substantial (kappa 0.74-0.80) for CHD and for all CVD as a group. There was high agreement (kappa 0.75-0.78) also for some specific conditions such as hypertension and diabetes. The lowest agreement (kappa <0.55) was found for low-back disorders, hip or knee arthrosis and claudication.

5.2 Health effects of smoking, alcohol consumption and physical activity

5.2.1 Morbidity (II)

The effect of the total amount and intensity of LTPA at the beginning of the follow-up on the risk of CHD, hypertension and NIDDM was studied in a cohort of 1340 men and 1500 women who were initially aged 35-63 years and who were followed for 10 years (study II). Among the men the total amount of LTPA was inversely associated with the risk of CHD and hypertension. For the lowest third of the total activity group an age- and smoking-adjusted relative risk of 1.98 (95 % CI 1.22-3.23) for CHD and an age-adjusted risk of 1.73 (95 % CI 1.13-2.65) for hypertension were found when compared with the highest third. Among the women the increased total amount of LTPA was associated with a decreased risk of NIDDM but not with CHD or hypertension. For the lowest third of the activity group an age-adjusted relative risk of 2.64 (95% CI 1.28-5.44) for NIDDM was found when compared with the highest third.

Weekly vigorous activity was associated with a decreased risk of hypertension among the men and NIDDM among the women. For the men with vigorous activity less than once a week, an age-adjusted relative risk of 1.56 (95% CI 1.07-2.28) for hypertension was found in comparison with that of the men with weekly vigorous activity.

Among the women the subjects with vigorous activity less than once a week had an age-adjusted relative risk of 2.23 (95% CI 0.95-5.23) for NIDDM when compared with those with vigorous activity at least once a week.

5.2.2 Mortality (III)

The effect of differently measured LTPA on the risk of all-cause and CVD mortality was analyzed for the men and women who were followed for 10 years and 10 months (study III). After adjustment for potential confounders, including smoking, an LTPA index based on energy expenditure and the participation in several specific activities of daily living and domestic chores showed that the mortality risk for all causes and CVD was highest for the most sedentary men. Similarly, the most sedentary women had an age-adjusted relative risk of 2.57 (95% CI 1.03 – 6.42) for all-cause mortality when compared with the most active fourth of the women. However, after further adjustment for potential confounders, LTPA was not associated with the risk of all-cause and CVD mortality among the women. Furthermore, due to the small number of deaths occurring among the women, the results should be interpreted cautiously. The single-item self-assessment of total LTPA and the compiled intensity-frequency assessment of activity were not associated with the risk of death among either the men or the women.

According to the LTPA index, the initially most sedentary fourth of the men had an increased risk of 2.74 (95% CI 1.46-5.14) for all-cause mortality and a risk of 3.58 (95% CI 1.45-8.85) for CVD mortality when compared with the most active fourth of the men. Of the 16 specified activities included in the LTPA index, leisure-time forestry work, gardening, and engine repair were the most strongly associated with the risk of all-cause mortality when potential confounders were considered. In the case of CVD mortality, caring for a vegetable garden, hunting, and leisure-time forestry work were the 3 activities most strongly inversely associated with the risk of death.

5.3 Economic consequences of smoking, alcohol consumption and physical activity

5.3.1 Use and costs of hospital care (IV, appendix 1 and 2)

Smoking increased the use of hospital services despite the length of the follow-up period, among both the men and the women after adjustment for age, socioeconomic or employment status, alcohol consumption and LTPA (study IV and appendix 1). During the 16-year follow-up, the current male smokers had 70% (95% CI 49-95%) and the female current smokers 49% (95% CI 29-71%) more hospital days due to any reason than those who had never smoked. Similarly, smoking increased the number of CVD-related hospital days among both the men and the women, while male smokers also had an increased use of injury- and accident-related hospital services. During the 9-year follow-up, the increase in the use of hospital services was reflected also in an increase in the costs of hospital services (appendix 2).

During the 16-year follow-up the men who were initially aged 19-63 years and who moderately consumed spirits or any type of alcohol had a decreased number of total hospital days compared with nondrinkers (study IV), while no association was found for the women or for the middle-aged and elderly men and women during the 11-year follow-up period (appendix 1). In comparison with the non-drinkers men who had an average of less than 1 drink per day (0.1-12 g) had 21% (95% CI 10-31%) fewer hospital days due to any reason during the 16-year follow-up after adjustment for age, socioeconomic status and smoking. The corresponding figure for the men consuming 1 drink or more per day (at least 12 g) was 15% fever hospital days (95% CI 1-28 %). When costs related to hospital care in the 9-year follow-up period were considered, the women using at least some alcohol had suggestively lower costs in relation to hospital services than the nondrinkers, while no effect was observed among the men (appendix 2).

A low level of the LTPA, when assessed by total energy expenditure, increased the number of hospital days due to any reason. During the 16-year follow-up period the men with a low level of total energy expenditure for LTPA had 36% (95% CI 15-63%) more hospital days after adjustment for age, socioeconomic status, smoking and alcohol consumption than the most active men did (study IV). The figure for the sedentary women

was 23% (95% CI, 4-44 %). During the 11-year follow-up period the low level of LTPA, assessed by the single-item self-assessment measure, was associated with an increased number of hospital days among the men but not among the women. The men with no weekly vigorous activity had 30% (95% CI 4-64%) more hospital days due to any reason than the men with vigorous activity at least once a week (appendix 1). When the costs related to hospital services during the 9-year follow-up period are considered, the women with no weekly vigorous activity had suggestively higher hospital service costs than the active ones, while no association was found for the men (appendix 2).

5.3.2 Use and costs of outpatient physician services (Appendix 1 and 2)

During the 5-year follow-up the male smokers initially aged 35-63 years had 19% (95% CI 3-38 %) more outpatient physician visits due to any reason than those who had never smoked when age, employment status, alcohol consumption and LTPA were adjusted in the models (appendix 1). The corresponding percentage for female past and current smokers was 15% (95% CI 1-30%). The increased use of outpatient physician services among both the male and female smokers was reflected also as a nearly statistically significant increase in the cost of related outpatient physician services (appendix 2).

Alcohol consumption was not associated with the outpatient-service-related utilization or costs of related outpatient services. Similarly, the level of LTPA was not associated with the utilization of outpatient physician services. The women with no weekly vigorous activity had nearly statistically significantly more costs for related outpatient physician visits than the women with vigorous activity at least once a week.

5.3.3 Use and costs of medication (Appendix 2)

Among the men smoking status, total alcohol consumption and LTPA had no effect on the costs accrued from the use of prescribed medication in 1990 (appendix 2). Similarly, no association between the selected living habits and medication costs were found among the women.

6 DISCUSSION

6.1 Validity of the data and methods

In the present study, conducted by an independent research group, health and economic consequences related to smoking, alcohol consumption and LTPA were assessed for a regionally representative cohort of middle-aged and elderly men and women with the use of a number of data sources. Most of the information, including that on living habits and sociodemographic factors, was gathered from questionnaires with high response rates.

The validity of the self-reported information about smoking, alcohol consumption and LTPA has been a topic of discussion in the literature for some time. In the present study smoking was considered as a categorical variable. In the earlier subsample analysis self-reported smoking status was found to be a relatively valid measure when it was compared with cotinine validation. Despite some single studies reporting relatively high misclassification rates (e.g, Heller et al. 1998) the findings are in agreement with those of 2 recent meta-analyses or reviews concluding high validity for self-reported smoking status (Patrick et al. 1994, Wells et al. 1998). A meta-analysis comparing self-reported smoking status with results of biochemical validation found that the sensitivity of self-reported smoking is 87% and the specificity is 89% (Patrick et al. 1994). The results suggested, however, that interviewer-administered questionnaires yielded somewhat higher estimates of sensitivity and specificity than did self-administered questionnaires (Patrick et al. 1994).

In the present study both the amount and frequency of the overall alcohol consumption (grams per day) and the use of spirits were assessed using questions derived from the population-based Mini-Finland Health Survey (Aromaa et al. 1989). In general, cohort studies with population-based samples are likely to miss or underrepresent total alcohol consumption, especially among alcoholics and other very heavy drinkers (Poikolainen 1985). In prospective epidemiological studies a simple self-administered questionnaire can provide useful estimates of moderate alcohol intake over an extended period of time, however (Giovannucci et al. 1991). In accordance with the method used in the present study, a recent review concluded further that, when there is sufficient evidence that alcohol intake is underestimated in a population, methods that inquire about both the

frequency and amount consumed, for beer, wine and liquor separately, yields realistic levels of intake (Feunekes et al. 1999).

The method most often used to examine the validity of self-reported levels of alcohol consumption has been a comparison with the volume derived from surveys of the volume derived from sales data (Poikolainen 1995, Rehm 1998). Thus far the results have been consistent in the sense that the self-reported volumes of alcohol consumption have not matched the sales figures (Rehm 1998). In the United States it has been reported that the difference between sales figures and self-reported volumes of alcohol consumption vary between 46% and 67% (Lemmens et al. 1992). It has been suggested that the validity of self-reported alcohol use may not only be dependent on the measurement, but also on the context in which the interview or survey is carried out (Midanik 1988). In the present study the use of alcohol consumption was assessed equally with other habits by a postal questionnaire with no special intention of disclosing problem drinkers. This procedure may help subjects to avoid the tendency to underestimate their alcohol consumption.

Epidemiological studies on physical activity and health have typically relied on questionnaires to obtain self-reports of the habitual level of physical activity because the questionnaire technique is a relatively inexpensive means of gathering data and questionnaires are easy to administer (Ainsworth et al. 1994). Questionnaire assessments have ranged from simple global questions to more extensive physical activity indices based on several questions. In an earlier review the possibility of misclassifying physical activity on the basis of a single baseline measure has been suggested (Blair et al. 1992). Therefore, it has been recommended that any increased or decreased risk demonstrated with a single point estimate of physical activity should be strengthened with a more complete and accurate, and less variable, measure of physical activity exposure (Blair et al. 1992).

In our data LTPA was assessed both by single-item self-assessments of physical activity and by a total LTPA index based on energy expenditure. The validity of a global self-assessment of LTPA has been found to be relatively good when compared with the results of the 2-km walking test, which can be used to estimate maximal aerobic power (Laukkanen et al. 1992). This finding agrees with current knowledge indicating that the repeatability and validity of global LTPA questions are good in comparisons with physiological validation parameters (Ainsworth et al. 1994).

A global self-report measure of LTPA does not provide detailed information about specific LTPA patterns or total energy expenditure, however. With the LTPA index conditioning exercise, sport, physical recreation, household chores and commuting to and from work could be exceptionally extensively estimated. In the current data the LTPA index was evidently describing life-style, including also activities that were not necessarily considered physical activity in a single question about physical activity. On the other hand, it has been suggested that for physical activity questionnaires, the logic of the questions is more important than the length of the questionnaire (Jacobs et al. 1993).

In addition to the data on living habits, the data concerning morbidity were derived from questionnaires. Due to the number of possible uncertainties associated with self-reported information about chronic diseases (Harlow and Linet 1989), the agreement and validity of the selected self-reported diseases in the present study were compared with the information obtained from the medical records of a random sample of middle-aged and elderly men and women (study I). The accumulated information about the occurrence of selected chronic diseases until March 1990 and the use of medication in 1990 were gathered manually from medical records kept by the care providers in the selected 3 health centers and the regional central hospital.

The results showed high agreement for well-known chronic diseases including CVD as a larger group, CHD, hypertension and diabetes. Our results resembled recent findings derived from self-reported questionnaires or interviews, which have indicated high agreement for diseases with clear diagnostic criteria and which are easily explained to the patient, including cancers (Colditz et al. 1986, Bergmann et al. 1998b) and diabetes (Midthjell et al. 1992, Heliövaara et al. 1993, Kriegsman et al. 1996). Similarly, the agreement between the self-reported information on hypertension, CVD as a larger group and recently also angina pectoris (Lampe et al. 1999) with data derived from medical records or physician examinations has been found to be high (Heliövaara et al. 1993, Kriegsman et al. 1996). Moderate agreement has also been found for such conditions as cerebrovascular diseases in other studies (Colditz et al. 1986, Heliövaara et al. 1993, Kriegsman et al. 1996, Bergmann et al. 1998a, Walker et al. 1998), while poor agreement has been reported for diseases with nonestablished criteria and a fluctuating course, such as musculoskeletal diseases (Heliövaara et al. 1993, Toomingas et al. 1995).

Overall, for middle-aged and elderly men and women, self-reported information about well-defined chronic diseases may provide accurate data with low costs (Midthjell et al. 1992), while self-reported information about diseases with less clear symptoms and diagnostic criteria is not suitable for replacing traditional medical examinations in epidemiological studies (Toomingas et al. 1995). Thereby the self-reported morbidity data of the present study probably offered a good basis for the further investigation of the association between the living habits in question and the risk of CHD, hypertension and NIDDM (study II).

In the present study the information on deaths was monitored using national census data since 1980 until the end of 1995. The validity of Finnish death certificates has been found to be high. For example, in a comparison of the CHD trends obtained from the national mortality statistics and from the FINMONICA myocardial infarction register for men and women under 65 years of age, the trends derived from 2 data sources were close for 1983-1992 (Mähönen et al. 1999).

The data concerning hospital services was based on records obtained from the Finnish Hospital Discharge Register. In Finland data on the use of hospital services have been gathered into this nationwide register from all public and private hospitals providing inpatient services since 1967 (Keskimäki and Aro 1991). It has been estimated that the overall correspondence between individual hospital discharge records and written patient histories for different diagnoses is nearly 95%, while the data of hospital admissions and discharges have been found to coincide exactly for 96% of hospitalizations (Keskimäki and Aro 1991).

In the costing of hospital admissions, the Finn-DRG based weights were used. The DRG system employed herein was an applied version of the well-known and largely adapted DRG system. It was developed initially to definite case types, each of which could be expected to receive similar services from a hospital (Fetter et al. 1980). The earlier form of DRG system has been criticized about the group heterogeneity in resource consumption (Grimaldi and Micheletti 1982) or severity of illness (Horn et al. 1983), for example, whereby the development of the system is still in progress (e.g., Averill et al. 1993, Freeman et al. 1995).

The data concerning outpatient physician visits, independent of the survey responses of the study subjects, was limited to 2 full calendar years (1985 and 1990) in 3 study municipalities. Therefore, the subjects (5%) aged initially 35-63 years who moved away from the study municipalities before 1 March, 1990 were excluded from the analysis. The men (n=77) and women (n=69) who moved away from the study municipalities were slightly younger and better educated than the study subjects included in the analysis. Due to the small number of cases and relatively minor differences in socioeconomic background factors between the included and excluded study subjects, the selected persons probably represent the original data well.

In order to determine the coverage of the data, the outpatient physician contacts recorded by the local health authorities and care providers were checked after each recording year against statutory medical files kept by care providers. After the data were supplemented with archives of the statutory medical files, the final material included about 90% of all registered outpatient visits made by the study subjects.

6.2 Health effects of smoking, alcohol consumption and physical activity

The major interest of the present study was the association of differently measured LTPA with several health-related outcomes. Smoking and alcohol consumption were used partly to compare the effects of common living habits and partly as potential confounding factors. Thus smoking was a strong predictor of mortality (study III) which agrees with a number of studies indicating that active and passive smoking are major preventable causes of death (USDHHS 1992, Bartecchi et al. 1994, Doll et al. 1994b, Peto et al. 1994, Hackshaw et al. 1997). As a consequence of consistently accumulating evidence on smoking-related health risks and the awareness of the population, the prevalence of smoking started to decrease in the beginning of the 1980's in several countries, especially among men (Vartiainen et al. 1994a, Helakorpi et al. 1998, Harkin et al. 1997, Arnett et al. 1998). During recent years smoking trends have been stabilized also among women in many countries including Finland (Helakorpi et al. 1998), but also increasing trends have been reported for some female populations, including southern Europe's and those of some former socialist countries (Harkin et al. 1997). If the present smoking trends among women continue,

smoking will still result in high levels of mortality in the future (Peto et al. 1994). Therefore, the unfavorable trends, especially among some female populations and several developing countries, stress the importance of the frequent need for antismoking strategies in public health policy (Harkin et al. 1997).

The health effects of alcohol consumption were minor in the data in respect to mortality, for example (study III). The role of alcohol consumption as a health-related risk factor is not unambiguous since, in some studies, protective effects have been obtained through the moderate consumption of alcohol (Beaglehole and Jackson 1992, Maclure 1993, Holman et al. 1996). In the present study the role of alcohol consumption may have been attenuated since most of the subjects, especially elderly women, were abstainers and only a minority of both the men and the women consumed one or more drinks of alcohol a day. Therefore, we were not able to consider the health effects of actual heavy drinking and thereby determine the shape of the curve when the association between the level of alcohol and morbidity or mortality was considered.

During the last decades the prevalence of alcohol consumption has increased among Finnish but also among Swedish women, for example (Helakorpi et al. 1998, Bengtsson et al. 1998). Another trend typical for recent decades has been the stabilized consumption of spirits and the increased use of beer, long drinks and cider among both men and women (Helakorpi et al. 1998). The current trends indicate that the role of public health policy in the future will be to prevent the development of problem drinking among the young in order to avoid later alcohol dependence and related diseases (Harkin et al. 1997).

The present study showed that an increased level of LTPA was associated with a decreased risk of premature morbidity (study II) and mortality (study III). When characteristics associated with the decreased risk of morbidity and mortality were investigated in more detail, the role of LTPA, consisting of numerous activities assessed according to energy expenditure, was stressed, as was the role of such single activities as leisure-time forestry work and gardening with respect to a decreased risk of all-cause mortality and growing vegetables, hunting and leisure-time forestry work for protection against CVD mortality. When the association between LTPA and morbidity was examined, it seemed likely that the protective effect of LTPA may differ among men and women and

the relative importance of the total amount and intensity of LTPA may vary depending on the outcome measure.

There is a continuing uncertainty about the intensity level of physical activity needed to attain various health benefits, such as a decreased risk of mortality and morbidity from CVD, CHD, hypertension and NIDDM (USDHHS 1996). The earlier findings concerning LTPA suggested that vigorous activity is required for disease and mortality protection (e.g., Morris et al. 1980). Until the early 1990's the physical activity recommendations emphasized especially the role of 20-60 minutes of continuous, moderately to vigorously intense activity sessions increasing and maintaining physical fitness (ACSM 1990). Even today it is argued that vigorous activities, but not nonvigorous activities, are associated with increased longevity (Lee et al. 1995). However, accumulated evidence suggests that significant health benefits can be attained also with lower activity levels (USDHHS 1996, Hakim et al. 1998, Manson et al. 1999), and therefore a dose-response relationship is indicated between LTPA and morbidity and mortality. In this study it was not completely possible to confirm a dose-response relationship between LTPA and morbidity and mortality due to the relative small sample size and the multidimensional measurement of LTPA, which likely described also the life-style of the study subjects.

The current widely accepted public health recommendation states that people of all ages should include a minimum of 30 minutes of physical activity of moderate intensity, such as brisk walking, in their schedules on most, but preferably all, days of the week. The activity can be done in one longer session or in several short bouts (Fletcher et al. 1995, Pate et al. 1995, NIH 1996, USDHHS 1996). The findings of the present studies seem to support these recommendations, although the intensity or continuousness of physical activity was not quantitatively assessed.

6.3 Economic consequences of smoking, alcohol consumption and physical activity

During the last few decades the total amount of health care expenditures has increased in several western societies, including Finland (Gerdtham and Jönsson 1994, Social Insurance Institution 1999). In 1997 the overall health care expenditures were FIM 46 316 million, which amounts to 7.3% of the gross domestic product (Social Insurance Institution 1999).

During the year in question inpatient and outpatient care comprised about three-fourths of the publicly financed health care expenditures in Finland.

According to the present study smoking was associated with an increase in the use of hospital and outpatient physician services and consequently with increased costs among both the men and the women when age, socioeconomic status and other living habits were adjusted in the model. The findings of the study agree with those of several investigations, which were however restricted to relatively short follow-up periods (Vogt and Schweitzer 1985). In comparison Wagner et al. (1995), for example, showed smoking to be associated with a 30-45% increase in hospital admissions and with a 7-15% increase in outpatient physician visits over about 5 years of follow-up.

The smoking-related studies covering lifetime-related health care costs have produced more conflicting results, however. The essential question seems to concentrate on the difference in the expected lifetime of smokers and nonsmokers, since the latter have more years to use health services (Barendregt et al. 1997) and expenditures dramatically increase from middle-age to the oldest ages (Gerdtham and Jönsson 1994, STAKES 1995, Meerding et al. 1998). In some views it has been suggested that, in countries with low mortality, the elimination of fatal diseases through successful prevention, for example, antismoking campaigns, increases health care costs because of life extension. Therefore the authors have concluded that only preventing disabling conditions, particularly mental disorders and musculoskeletal problems (Bonneux et al. 1998) will achieve major savings.

In the present study the role of alcohol consumption in health care utilization and costs was minor. This minor role may be, at least partly, due to the lack of actual problem or heavy drinkers in the data, since these people have been shown to be heavy users of health services (Holder 1987, Adams et al. 1993, Salomaa 1993, Muller 1996, Devlin et al. 1997) and they also cause a number of other costs (Salomaa 1993, Devlin et al. 1997). Smoking often compounds the effects of alcohol consumption, and, when combined the two are a source of such individual and environmental problems as, for example, residential fires (Salomaa 1993). Alcohol abuse is also related to several other cost items, including those connected with crime and motor vehicle accidents (Salomaa 1993, Devlin et al. 1997). Therefore, in some investigations, it has been suggested that alcohol-related

costs to society are even higher than those caused by smoking (Luce and Schweitzer 1978, Manning et al. 1989).

According to the present study a low level of LTPA, assessed by energy expenditure, was associated with an increase in the use of hospital services during the 16-year follow-up of both men and women. The role of LTPA intensity was emphasized for sedentary men, who used hospital services more heavily than those with vigorous activity. There was no association between the level of LTPA and the use of outpatient physician services or medication among the men or the women, however. In contrast to the use of health services, the sedentary women had suggestively higher health care costs for hospital and outpatient physician services than more active women did.

Thus far relatively few studies have considered the economic aspects of LTPA by examining actual data, and even fewer have used a longitudinal study design with the same study subjects. Therefore, these studies include a numerous assumptions that may lead to bias. Most of the few studies concerning the role of LTPA in the use of health services have stressed exercise rather than LTPA (Hatziandreu et al. 1988, Reijnen and Velthuijsen 1989, Nicholl et al. 1994, Stam et al. 1996, Munro et al. 1997). Exercise is characterized by planned and structured activity to improve or maintain one or more components of physical fitness, while in the present study, for example, two-thirds of the subjects' weekly energy expenditure was carried out through daily living and domestic chores. Therefore, the role of sports injuries in health care utilization was probably emphasized more in earlier studies than in the present one, while the role of musculoskeletal disorders and injuries occurring in daily domestic chores was likely higher in the present study than in earlier investigations.

The present study and the other few investigations suggest that the difference in health care costs among sedentary and active subjects seems to be minor. Despite the minor or no economic savings, the results support the notion that participation in regular LTPA brings significant health benefits and therefore the promotion of physical activity should be part of public health policy. At the same time it is important to pay attention to the safety aspects of all kinds of physical activity.

Moreover, the present results compounded with current evidence concerning the economic consequences of each of the studied living habits showed the methodological complexity related to these issues. The numerous health effects related to living habits may reflect these conflicting results in terms of the use and costs of health services depending on the viewpoint, time period, potential confounders, method of determining costs, and discount rate.

7 CONCLUSIONS

The series of presented studies warrant for the following conclusions:

The agreement between self-reported diseases in a questionnaire survey and data from medical records was good for well-known chronic diseases that have clear diagnostic criteria and that are easily explained to the patient. These diseases include CVD as a group, hypertension, angina pectoris, myocardial infarction, and diabetes. Conversely, the agreement was poor for diseases with unestablished diagnostic criteria and a fluctuating course, including hip or knee arthrosis and low-back disorders.

Among the middle-aged and elderly men of the present study a physically active life-style had a protective effect against CHD and hypertension, while among the women a protective effect against the risk of NIDDM was evident. An increased level of LTPA, assessed as an index giving an estimate of weekly energy expenditure for leisure-time activities as well as commuting to and from work and participation in several specific activities of daily living, was protective against death from all causes and CVD.

The numerous health benefits of non-smokers and physically active subjects, compared with current smokers and sedentary men and women, were reflected also as a lower use of health services, especially in the form of a decrease in the use of hospital services. The impact of smoking was seen also as increased health care costs, but this effect was modest in the case of low-level LTPA.

8 SUMMARY

The primary purpose of this study was to assess and compare, in the context of public health policy, the role of smoking, alcohol consumption and LTPA for health and health care utilization during a 16-year follow-up period among middle-aged and elderly men and women. Most of the morbidity data were based on responses to a self-administered questionnaire, and the purpose of study I was therefore to ensure the valid use of questionnaire-based morbidity data. As a consequence, in study I, the agreement between selected self-reported diseases in a questionnaire survey and data from medical records was assessed using a random sample of men and women (n = 596) initially aged 35-63 years. The agreement between the two sources was substantial (kappa 0.73-0.80) for CVD as a group, hypertension, angina pectoris, and diabetes. In accordance with current evidence, the lowest agreement (kappa < 0.55) was found for low-back disorders, hip and knee arthrosis, and claudication. The findings indicate good agreement between questionnaire data and medical records for well-known chronic diseases that have clear diagnostic criteria and that are easily explained to the patient. Conversely, the agreement seems to be poor for diseases with unestablished diagnostic criteria and a fluctuating course.

Study I indicated that self-reported information on CHD, hypertension and diabetes is likely to be valid. Thereafter study II was designed to determine the effect of these selected diseases and LTPA in a cohort of 1340 men and 1500 women initially aged 35-63 years during a 10-year follow-up. Among the men, an active life-style decreased the risk of CHD and hypertension, while among the women a protective effect against NIDDM was found. The results indicate that the protective effect of LTPA can differ for men and women, and the relative importance of the total amount and the intensity can vary depending on the outcome measure. Differences in the type of LTPA in which men and women are engaged may also lead to different health-related effects.

Study III was targeted to investigate the effect of LTPA on the risk of premature all-cause and CVD mortality in a cohort of men and women initially aged 35-63 years in a 10-year, 10-month follow-up period. A high level of LTPA, as assessed by a physical activity index computed as an estimate of weekly energy expenditure for leisure-time activity and commuting to and from work, and participation in several specific activities of daily living and domestic chores, including forestry work, gardening and growing

vegetables, had a protective effect against premature mortality from both all causes and CVD. Therefore, in this study sample, representing a rural region of Finland, the results highlight the role of the total amount of activity through an active way of life, as also recommended in recent physical activity guidelines.

Study IV was targeted to examine the effect of smoking, alcohol consumption, and LTPA on the use of hospital services among a cohort of 19- to 63-year-old men (n = 2534) and women (n = 2668) followed for 16 years. In accordance with the morbidity and mortality data of the overall project and also the results of others, male and female non-smokers and physically active subjects used hospital and outpatient physician services less than current smokers and physically inactive subjects. During the 16-year follow-up the initially 19- to 63-year-old male smokers had 70% (95% CI 49-95%) more hospital days due to any reason than the never smokers did, and the female smokers had 49% (95% CI 29-71%) more such days after adjustment for age, socioeconomic status, and total alcohol consumption (study IV). The increased use of hospital days and outpatient physician visits among male and female smokers was reflected also as increased costs for health care compared with never smokers (appendix 2). Similarly, in comparison with the most active men, those with a low level of total energy expenditure during LTPA had 36% (95% CI 15-63%) more hospital days after adjustment for age, socioeconomic status, smoking and total alcohol consumption. Sedentary women had 23% (95% CI 4-44%) more hospital days than women who were physically active. Surprisingly, however, the increased use of hospital care among physically inactive men was not reflected as an increase in costs for hospital care (appendix 2). In contrast to the numerous studies showing J- or U-shaped alcohol-related health effects, alcohol consumption did not determine the use of hospital services in this study. This relationship may have been attenuated, at least partly, by the small number of high-volume drinkers, especially among the women.

Overall, smoking, excess alcohol consumption and low-level LTPA were important risk factors for morbidity and mortality. Smoking and low-level LTPA increased the utilization of health care services, especially the use of hospital services. Surprisingly, however, the impact of smoking on health care costs was substantial, while that of low-level LTPA was not. The results support the objectives of public health policy that advocate a reduction of the prevalence of poor living habits as a means of improving the

functioning and quality of life of the population, preventing its suffering from premature morbidity, and prolonging its survival.

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