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Karolinska Institutet, Stockholm, Sweden

WORK ABSENTEEISM AND PRODUCTIVITY LOSSES ASSOCIATED WITH OVERWEIGHT

Kristian Neovius

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ABSTRACT

Background Overweight has increased dramatically in the Western world during the past decades. The condition is associated with impaired health through, e.g., cardiovascular disease, musculo-skeletal disorders, type II diabetes, sleep apnoea and cancer. Apart from causing individual suffering, overweight incurs costs to society.

Aim The aim of the present thesis was to investigate the association between overweight and work absenteeism, as well as the related productivity losses to society.

Methods Data on individual characteristics, e.g. body mass index (BMI; kg/m^2), smoking, socio-economic index and muscular strength, as well as data on sick-leave, disability pension and mortality, were obtained for 45 920 Swedish men performing mandatory military service conscription tests in 1969/70 (mean age 18.7±0.5y) through linkage of national registers. Overweight was classified into pre-obesity (BMI 25.0-29.9) and obesity (BMI≥30.0), while normal weight was defined as BMI 18.5-24.9.

Based on 38y of follow-up from time of conscription tests, overweight-related risks compared to normal weight for sick-leave, disability pension and premature death were estimated by the use of multivariable regression models. The related productivity losses were estimated using the human capital approach.

Results Compared to normal weight, overweight was found to be associated with increased risk of work absenteeism, especially for longer episodes (including death). During a lifetime, an obese individual was estimated to incur productivity losses to a value of €95 000 ($CI_{95\%}$ €89 000 - €103 000) to society, nearly twice as much as his normal weight counterpart. Approximately 8% of future productivity losses among young men today could be avoided, had no one been overweight.

Conclusion Overweight-related costs of work absenteeism appear to be significant and are important to consider in decision making. Effective overweight prevention has the potential to substantially reduce productivity losses to society.

LIST OF PUBLICATIONS

I. Neovius K, Neovius M, Kark M, Rasmussen F.
Association between obesity status and sick-leave in Swedish men: nationwide cohort study.
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CONTENTS

1 Background ... 1
1.1 Overweight ... 1
1.2 The overweight epidemic ... 1
1.3 Health consequences of overweight ... 2
1.4 Costs of overweight ... 2
1.4.1 Health care costs ... 2
1.4.2 Productivity losses ... 3
1.5 Objectives ... 6
1.6 Ethical considerations ... 7
2 Methods ... 8
2.1 Data and study populations ... 8
2.1.1 Registers ... 8
2.1.2 Study populations ... 9
2.2 Outcomes ... 10
2.2.1 Sick-leave ... 10
2.2.2 Disability pension ... 10
2.2.3 Mortality ... 11
2.3 Predictors ... 11
2.3.1 Body mass index (BMI) ... 11
2.3.2 Socio-economic index ... 11
2.3.3 Smoking ... 12
2.3.4 Muscular strength ... 12
2.3.5 Geographical region ... 12
2.3.6 Municipality ... 12
2.4 Statistical analysis ... 13
2.4.1 Cox regression ... 13
2.4.2 Weibull model ... 13
2.4.3 Logistic regression ... 13
2.4.4 Markov model ... 14
2.4.5 Monte Carlo simulation ... 14
2.4.6 Population attributable fraction ... 15
2.4.7 Interaction ... 16
2.5 Estimation of productivity losses ... 17
2.5.1 Human capital approach ... 17
2.5.2 Friction cost method ... 17
3 Results ... 18
3.1 Overweight-related risk of work absenteeism ... 18
3.2 Productivity losses associated with overweight ... 19
3.3 Effect of overweight on the population level ... 19
4 Discussion ... 21
4.1 Main results ... 21
4.2 Comparison with previous studies ... 21
4.3 Causality ... 22
4.4 Strengths and limitations ... 23
4.5 Policy implications ... 24

4.6 Directions for future research 24
4.7 Conclusions 25
5 Acknowledgements 26
6 References 27

1 BACKGROUND

1.1 OVERWEIGHT

Fat is a highly efficient tissue for energy storage and is crucial for the normal physiology of human beings. However, excess body fat may result in adverse health consequences.

In 1997, the World Health Organization (WHO) endorsed body mass index (BMI), calculated as the weight divided by the height squared (kg/m^2), as the standard measure for the condition of excess body fat. While often used to represent the condition per se, "obesity" is at the same time a level within the BMI-based classification system (BMI≥30 kg/m^2), which can cause terminological confusion. In **Table 1** the WHO classification of adult underweight, normal weight, overweight and obesity according to BMI is shown. This classification defines overweight as any BMI above the normal weight range, and obesity as a level of overweight.

To avoid confusion, and based on the WHO's classification, the condition of excess body fat as such will be referred to as "overweight" throughout this thesis; BMI between 25.0 and 29.9 as "pre-obesity" and BMI≥30.0 as "obesity".

Table 1: The International Classification of adult underweight, overweight and obesity according to BMI (Source: WHO[1])

Classification	BMI (kg/m^2) Principal cut-offs points
Underweight	**<18.50**
Severe thinness	<16.00
Moderate thinness	16.00-16.99
Mild thinness	17.00-18.49
Normal range	**18.50-24.99**
Overweight	**≥25.00**
Pre-obese	25.00-29.99
Obese	**≥30.00**
Obese class I	30.00-34.99
Obese class II	35.00-39.99
Obese class III	**≥40.00**

1.2 THE OVERWEIGHT EPIDEMIC

The prevalence of overweight has increased dramatically in the Western world during recent decades, and has today reached proportions that are often referred to as epidemic. In the United States in 2010, more than 60% were overweight, of which about half were obese[2]. In Europe, the highest prevalence of obesity is found in the UK (approximately 25%)[3]. Among industrialised countries, Japan differs with a prevalence of obesity of only a few percent[3].

In Sweden, obesity has quintupled (from 0.8% to 5.5%) and pre-obesity has tripled (from 5.7% to 15.6%) during the last decades among Swedish men performing mandatory military conscription tests (**Figure 1**). If this trend would continue, obesity could approach 20% among young Swedish men by 2030.

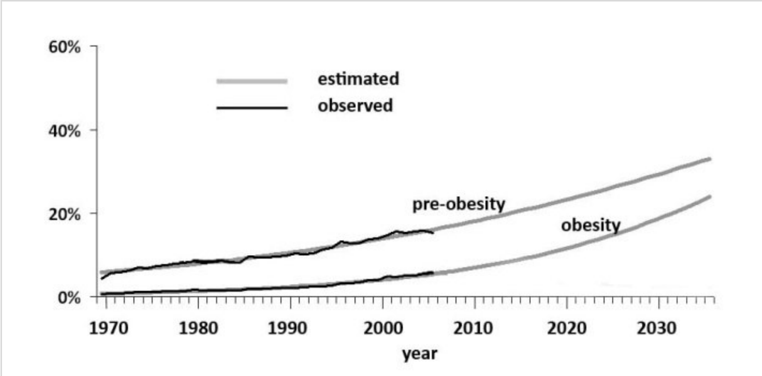

Figure 1 Observed (1970-2005) and projected (2005-2035) prevalences of pre-obesity and obesity among Swedish men performing mandatory military conscription tests[4].

Recent studies have suggested that the obesity prevalence has levelled off in several countries since the early 2000s[5]. In an extensive review of the subject published in 2010, Rokholm et al. concluded that the majority of the studies regarding both children and adolescents showed a levelling off in the prevalence of obesity[5]. However, it is too early to call off the efforts to halt the overweight epidemic based on this evidence. Furthermore, overweight has in some cases been shown to increase stepwise rather than continuously[6]. In any case, the current prevalence is historically high.

1.3 HEALTH CONSEQUENCES OF OVERWEIGHT

Excess body fat can have detrimental health effects. Overweight has been found to be a risk factor for several health conditions such as cardiovascular disease, type II diabetes mellitus, sleep apnoea, musculo-skeletal disorders and cancer[7], and the increased mortality risk due to overweight is well documented[8-10].

Not all studies of overweight and mortality have found an increased risk for the pre-obese category. In a large prospective study using data from the National Health and Nutrition Examination Survey (NHANES) in the US, for example, pre-obesity was not associated with increased mortality risk[11]. A possible explanation for the absence of increased mortality risk among the pre-obese could be reverse causality due to short follow-up periods where some individuals in the lean reference group have low weight due to impaired health[12]. Also, it is important to accurately adjust for smoking in studies of overweight and mortality, since smoking is associated with both low weight and elevated mortality[12].

1.4 COSTS OF OVERWEIGHT

The cost consequences of a disease are commonly expressed as the excess costs due to the condition, e.g. costs attributable to overweight in excess of what would be expected in normal weight individuals. It is common to divide these costs into health care costs and costs related to productivity losses (sometimes also referred to as indirect costs).

1.4.1 Health care costs

Obesity alone has been estimated to be responsible for 0.7-2.8% of health care expenditures worldwide, and if pre-obesity is included this number approaches 10%[13]. In Sweden, the health care costs of obesity have been estimated to 1.7 billion SEK in 2003 (3.6 billion SEK if pre-obesity was also considered)[14].

These studies used a cross-sectional design where the costs of overweight are estimated for a certain population at a certain point in time. The results indicate that effective policies to promote healthier weight could also have economic benefits.

An alternative approach to estimate the costs of overweight is to use a longitudinal design. Van Baal et al. estimated that an obese individual accumulated an average of €250 000 in health care costs from age 20y until death, while a normal weight individual accumulated €280 000[15]. The obese individual incurred higher health care costs during each time period during life, but since obesity reduces longevity the high health care costs associated with old age were avoided by the obese individual, and the costs over a lifetime were actually smaller than for the normal weight individual. This is in contrast to the results from the cross-sectional studies, where it is claimed that overweight is an economic burden for the health care system.

The study by van Baal et al. was based on a simulation model where data were extrapolated far into the future, and was therefore afflicted with high uncertainty. Also, other studies using a similar design had contradictory results[16-21]. However, the main difference between the cross-sectional costs studies, indicating that avoided overweight would result in health care savings, and the longitudinal study by van Baal et al., indicating the opposite, was the consideration of costs during added years of life. According to van Baal et al., effective overweight prevention would initially decrease the health care costs for a given cohort, but the costs that occur during the extra years of life gained through the prevention more than weigh up these savings. The cross-sectional studies, on the other hand, are often based on calculations of how much an overweight-related disease costs the health care system, which is multiplied with a factor representing how much of that cost is attributable to overweight. In these studies, with increased relative risks for overweight compared to normal weight of the diseases considered, overweight can only result in increased costs. Savings from avoided health care in old age are generally not included.

1.4.2 Productivity losses

Productivity losses are the value of production foregone due to an individual's unperformed work[22 (p. 84)]. The productivity losses are not solely borne by the individual himself, since he or she is often covered by some kind of insurance and the income is only marginally affected. Instead, the productivity losses are to a great extent borne by the other individuals in society[23]. Often the terms "indirect cost" and "productivity losses" are used synonymously, but indirect costs could also refer to, e.g., suffering and decreased quality of life, which should not be considered as productivity losses.

Productivity losses are calculated as the work time foregone multiplied by the value per time unit of this work. The value of the work time can be estimated as the employee's gross income including all social fees, since this is what the employer actually pays for the work to be done[22 (p. 84)]. The fact that salaries differ between groups, e.g. between young and old, men and women, obese and normal weight, could raise a problem. If, for example, a lower salary for women than men is used, the productivity losses associated with the same amount of work foregone would be higher for men than for women. If these productivity losses were to be used in economic evaluations of treatments, the analyses would be biased towards more favourable results for men and thus discriminate against women, given that women are paid less for the same work.

The estimation of work time foregone is less straightforward than the estimation of the value per time unit. There are two main ideas of how the work time foregone should be estimated: the human capital approach and the friction cost method.

Human capital approach: Using the human capital approach, the total time that the employee is unable to work is considered and multiplied with the value per time unit[24]. If an individual becomes a disability pensioner five years before age of retirement, every single hour of unperformed work during these five years is multiplied by the value per time unit.

Friction cost method: According to advocates of the friction cost method, the human capital approach estimates the *potential* productivity losses, which is looked upon as an overestimation of the *actual* productivity losses[25]. In reality, they argue, colleagues cover up for the absent worker to some degree during a shorter sick-leave episode, and the work can also partly be made up for by the sick employee on his return. In case of disability pension or death, and also longer episodes of sick-leave, the absent worker will be replaced by someone in the pool of unemployed after some time. Therefore, the work time foregone should be decreased with a certain factor, and after a period referred to as the ”friction period” there is no work time foregone anymore since the individual has been replaced.

Advocates of the human capital approach argue that the friction cost method is based on assumptions that violate neoclassical economic theory, and that the use of friction periods is not practically doable since one initial absence triggers a chain of replacements and friction periods, which would have to be tracked and quantified[24]. However, it should be noted that the human capital approach lacks support by economic welfare theory, since the consequences of lost production are not expressed in utility[26 (p. 23)].

1.4.2.1 Productivity losses associated with overweight

Productivity losses can occur as a consequence of presenteeism (being unproductive at work) or work absenteeism (sick-leave, disability pension or death before age of retirement). Below, findings regarding the associations of overweight and the elements of productivity losses are presented.

1.4.2.1.1 Overweight and presenteeism

Presenteeism is a term used for workers who are not absent from work, but who have decreased productivity. The outcome as such is difficult to measure. Only a few studies have investigated the association between overweight and presenteeism, all performed in the US[27-31]. Three of the studies found decreased productivity from presenteeism among overweight individuals[27 29 30], while two reported a weak or no association[28 31].

1.4.2.1.2 Overweight and sick-leave

Sick-leave is generally defined as a temporary absence from work due to health problems. A sick-leave episode can range from a few days to months and even years. Several studies have investigated the association between overweight and sick-leave[32-41]. In general the studies indicate that obesity is associated with increased risk of sick-leave, especially for longer episodes. For pre-obese individuals existing data are conflicting, with slightly increased risk or no increased risk of sick-leave. Many of these studies have been limited to specific professions and short follow-up periods. Also, comparison between the studies is hampered by different definitions of sick-leave and overweight.

1.4.2.1.3 Overweight and disability pension

Disability pension is usually granted to individuals unable to continue work due to medical conditions resulting in permanently reduced work ability. Studies investigating the association between overweight and disability pension have generally been of high quality with large, representative populations and long follow-up periods[42 43]. Results to date have revealed a J-shaped relationship, with increased risks for underweight as well as pre-obesity and obesity. Musculo-skeletal, circulatory and mental disorders have been found to be the main causes[44 45].

1.4.2.1.4 Overweight and mortality

As mentioned, large studies have documented the increased mortality risk associated with overweight[8-10], although some controversy remains whether the risk is increased for the pre-obese, or only for the obese[11 12].

1.4.2.1.5 Estimated productivity losses of overweight

Existing studies on the productivity losses associated with overweight have predominantly used a cross-sectional design, i.e. calculated the costs of overweight for a certain country during a certain year[30 46-48]. Since different populations have been investigated and different definitions of levels of overweight have been used, and since different elements of productivity losses (presenteeism, sick-leave, disability pension and premature death) have been included, the results have a wide range. None of the studies used the friction cost method.

Often the productivity losses associated with overweight have been found to be higher than the corresponding health care costs. In China in the year 2000, the productivity losses associated with obesity were estimated to be seven times greater than the health care costs[49]. Similarly in Sweden in the year 2003, the productivity losses associated with overweight were estimated to be more than three times greater than the health care costs of overweight (12.4 billion SEK compared to 3.6 billion SEK)[47].

Narbro et al. estimated the annual productivity losses for obese Swedish women in the early 1990's to be 2.2 to 3.6 billion SEK, considering sick-leave and disability pension only, which was about 10% of total annual productivity losses originating from sick-leave and disability pension among women[50].

In summary, existing evidence suggests that productivity losses associated with overweight can be substantial, maybe even greater than the corresponding health care costs. However, existing estimates of overweight-related productivity losses have mainly been based on a cross-sectional approach without a time dimension. For decision making, it is important to account for the time between investment and future benefits. Therefore a longitudinal approach to the productivity losses of overweight is needed.

1.5 OBJECTIVES

The overall objective of this thesis was to investigate the association between overweight and work absenteeism with its related productivity losses from a societal perspective.

The specific objectives were

1. to investigate the association between overweight and risk of sick-leave (study I)
2. to investigate the combined effects of overweight and smoking on subsequent disability pension (study II)
3. to investigate the effect of past and future trends in overweight and smoking on premature death (study III)
4. to estimate the lifetime productivity losses associated with overweight (study IV)

1.6 ETHICAL CONSIDERATIONS

The studies included in this thesis describe consequences of overweight in terms of work absenteeism and productivity losses, and provide information for decision making. The individuals of the cohorts used will not benefit in a direct way of this research, but since the decision making aims at using the limited resources of society in a more effective way, all individuals of society may benefit indirectly.

There is a potential risk of perceived violation of personal integrity when using data associated with individuals' characteristics and lifestyle choices, such as BMI and smoking. However, this risk may be considered to be small compared to the benefits of new knowledge for society. In addition, this thesis is based on de-identified register data, and the results are only presented on the group level.

This thesis is based on studies of men only. This is exclusively due to the fact that no comparable data to that in the Military Service Conscription Register data currently exist for women in Sweden.

Ethical approval for the studies of this thesis was granted by the Regional Ethical Review Board, Stockholm, Sweden (reference number: 2008/961-31/3).

2 METHODS

2.1 DATA AND STUDY POPULATIONS

2.1.1 Registers

Based on the unique personal identification number assigned to each Swedish resident a dataset was created by register linkage between the Military Service Conscription Register, the Social Insurance Register, the Register of the Total Population, the Population and Housing Censuses, and the Cause of Death Register. The registers are briefly described below.

2.1.1.1 Military Service Conscription Register

Universal conscription was introduced in 1901 in Sweden, and was enforced by law for men until 2010. After 2007 only individuals who passed a questionnaire regarding suitability for service were selected for conscription tests. Today, Sweden has a professional army.

The conscription tests normally took place during the last year of high-school (age 18-19y) and were completed during one or two days. The tests included anthropometry (height and weight measured by trained professionals), physical tests (endurance and muscular strength), blood pressure and resting heart rate measurements, IQ-test, a questionnaire about childhood, school, work and alcohol and tobacco habits, as well as a structured interview by a psychologist. The data have been computerised and are available for research.

2.1.1.2 Social Insurance Register

The Swedish Social Insurance Office holds a register over sick-leave episodes and granted disability pensions. Data on sick-leave episodes are only available after 1986. Since both the disability pensions and sick-leave episodes result in economic compensation, the quality of the register is expected to be good. However regarding sick-leave, the employer has been responsible for the compensation during the first period of the absence (14/21/28 days) since 1993, and therefore this period has not been registered by the Social Insurance Office.

2.1.1.3 Register of the Total Population

Since 1968 Statistics Sweden holds a register of the total population based on information from tax administration. The register includes data on births, deaths, changes in marital status, immigration and emigration since 1966. It has national coverage and is considered to be of high quality[51].

2.1.1.4 Population and Housing Censuses

Between 1960 and 1990 a compulsory population and housing census was performed every five years. The resulting register contains information about individuals (e.g. regarding occupation and education) as well as households (e.g. regarding number of individuals in the household and income). It has national coverage and the quality is considered to be high, with a non-participation rate of only 2.5% in 1990[52].

2.1.1.5 Cause of Death Register

This register is kept by the National Board of Health and Welfare and contains information on all deaths and causes of death in Sweden from 1961. The causes are coded according to the International Classification of Diseases (ICD). It has national coverage, but may lack data on emigrated individuals.

2.1.2 Study populations

In this thesis two cohorts from the Military Service Conscription Register were used, namely the individuals performing tests 1969/1970 and 2004/2005. Also, in an analysis of the trends in BMI, all conscription cohorts between 1969 and 2005 were used.

2.1.2.1 The 1969/70 cohort

The individuals performing conscription tests the years 1969 and 1970 constituted the main cohort for the analyses. Registered data on smoking habits on an individual level during these years was the reason for choosing this particular cohort. At the time the Military Service Conscription Register was in its initial phase, and data on all conscripts were not available. From the tests 1969/70, a total of 50 398 men can be found in the register, of which the majority was born in 1951 and fewer in 1950 and 1949. Since there was no systematic selection in the process of entering data into the register, the cohort is expected to be representative for all men in Sweden of the same age.

Of the 50 398 men in this cohort, 889 were excluded from the analyses due to missing data on smoking habits; 951 due to height/weight/BMI outside plausible limits (≤150 or ≥210 cm for height, ≤40 or ≥150 kg for weight and ≤15 or ≥60 for BMI) in order to minimise errors of misclassification; and 2771 due to being younger than 16y or older than 20y at the time of the conscription test. The age limitation was applied since individuals with very early or late timing of conscription tests could differ in other aspects too.

2.1.2.2 The 2004/05 cohort

For study III the cohort performing conscription tests in 2004 and 2005 was also used. At the time all men were still inducted to conscription tests, but data were only registered for those finally chosen for service. A total of 94 219 men performed the tests 2004/2005, of which 60 360 had their data registered (64%). After the exclusions mentioned above 56 411 men remained for analysis.

The generalisability of this cohort can be questioned, since a systematic selection was introduced regarding the registration of data from the conscription tests. A closer look at the socio-economic index of the individuals in the Military Service Conscription Register between 1997, when all men still had their test data registered, and 2005 revealed that the proportion of conscripts with higher socio-economic index had increased over the period. Given that high socio-economic index is associated with lower BMI, this indicates that the prevalence of overweight for the 2004/05 cohort may be underestimated in these data compared to the total population of young Swedish men.

2.1.2.3 All cohorts 1969 - 2005

To enable projections of future prevalence of overweight in study III, trends in overweight were investigated in all cohorts performing conscription tests between 1969 and 2005 (n=1.6 million individuals).

2.2 OUTCOMES

In this section, the outcomes used in the analyses are described. Data on the outcomes were retrieved from the Social Insurance Register (sick-leave and disability pension) and from the Cause of Death Register (mortality).

2.2.1 Sick-leave

A sick-leave episode was defined as time-limited absence from work (or inability to search for a job when unemployed) due to illness, injury or rehabilitation. “Illness premium” (sjukbidrag) was therefore defined as sick-leave, even though the duration can be up to a year or longer.

Data on sick-leave were available for the conscription cohort 1969/70 from 1986 to 2005. In 1992, “sick-pay” (sjuklöneperiod) was introduced, moving the responsibility for the economic compensation during a first period of a sick-leave to the employer. Therefore, sick-leave episodes shorter than 14 days (or 21/28 days, for certain years) were not registered by the Social Insurance Office after 1992.

Sick-leave episodes can be part-time or full-time (25%, 50%, 67%, 75% or 100%). In study I, sick-leave episodes were divided into ‘short-term’ (1-7 days), ‘intermediate-term’ (8-30 days) and ‘long-term’ (>30 days) episodes, since risks may differ between the categories. The short-term episodes were believed to reflect shorter absences due to, e.g., minor illness; intermediate-term episodes more serious illnesses (a sick-leave longer than one week requires a physician’s certification); and long-term episodes more serious illnesses such as musculo-skeletal or psychiatric disorders. The categorisation only considered the absolute number of days absent from work, e.g., an absence of 32 days at 50% extension (part time) was regarded as a long-term episode (>30 days), even though the net number of workdays lost only were 16.

In study I, overweight-related risk of sick-leave was investigated for the whole period 1986-2005 only for long-term episodes. Short- and intermediate-term episodes were investigated for the period 1986-1992, since the sick-pay periods have not been registered.

2.2.2 Disability pension

Disability pension is a form of preterm retirement for individuals who are considered unable to return to employment for the rest of their lives due to medical conditions. Data on disability pensions were available for the conscription cohort 1969/70 from 1969 to 2007.

In 2003, the term “disability pension” was changed to “illness compensation” (sjukersättning) for individuals 30-64y old with impaired ability to work in a life-time perspective, and to “activity compensation” (aktivitetsersättning) for individuals 19-29y old with impaired ability to work due to medical conditions by ≥25% for at least one year. Unlike illness compensation (and former disability pension), activity compensation is time-limited. By 2003, the 1969/70 conscription cohort used in the studies of this thesis was not eligible for activity compensation due to age. Therefore the term "disability pension" has also been used for the illness compensations granted during 2003 to 2007.

The term "Illness premium" (sjukbidrag) was changed to "time-limited illness compensation" (tidsbegränsad sjukersättning) in 2003. Since this kind of absence is limited in time it was defined as sick-leave in the analyses, and was therefore not considered in the study of overweight-related risk of disability pension (study II).

Disability pensions can be part-time or full-time (25%, 50%, 67%, 75% or 100%). In study II, the outcome was defined as a granted disability pension of any kind.

2.2.3 Mortality

The timing of deaths from all causes for the conscription cohort 1969/70 was retrieved from the Cause of Death Register during the years 1969 to 2007.

2.3 PREDICTORS

The primary predictor in the analyses was BMI as a proxy for overweight. Covariates used in the models in order to minimise confounding were socio-economic index, smoking and muscular strength, as well as geographical region and municipality in study II. Age was not included in the models, as age restrictions had been applied and the cohort therefore was reasonably homogeneous in this regard.

2.3.1 Body mass index (BMI)

BMI is a crude measure of overweight. Calculating the weight divided by the height squared (kg/m^2), it does not reflect body composition (i.e. proportions of body fat and muscle mass), which can lead to misclassification of e.g. athletic individuals that have a high body mass due to a high proportion of muscle mass. Also, it does not reflect fat distribution (i.e. where on the body the fat is located). Information on fat distribution is of importance since abdominal fat has been shown to be associated with greater health hazards than more peripherally accumulated fat[53]. Furthermore, BMI has poor specificity and sensitivity as a measure of overweight[54]. Nevertheless, BMI can be useful since it is simple to calculate, feasible to use in large epidemiological studies, and is fairly strongly correlated with better measures of overweight, such as Dual-energy X-ray absorptiometry (DXA)[55].

In the analyses of this thesis, BMI was categorised into the WHO defined categories underweight (<18.5), normal weight (18.5-24.9), pre-obesity (25.0-29.9) and obesity (≥30.0), where the latter two both belong to the overweight category (Table I). This is not completely congruent with the specific studies of this thesis, where the condition of excess body fat is referred to as "overweight" and "obesity" alternately, and BMI 25.0-29.9 as "overweight".

2.3.2 Socio-economic index

Overweight was not evenly distributed over categories of socio-economic index in the 1969/70 conscription cohort. Since socio-economic index also was associated with the outcomes and therefore affected the overweight-related risks, the analyses were adjusted for socio-economic index.

Data on profession from the Population and Housing Census were used to assign a socio-economic index to each individual in the 1969/70 conscription cohort. Data on profession were available for 1970 and 1990. In 1970, the age of the cohort was about 19y and the majority had probably not entered the labour market yet. Therefore, the highest socio-economic index (based on profession) of the parents in 1970 was used to define socio-economic index of the individuals in the cohort. Socio-economic index was categorised into blue collar (manual workers), white collar (clerks), self-employed and other.

2.3.3 Smoking

The deleterious effects of smoking on health are well-known[56]. Being associated with low weight, smoking is an important confounder of the overweight-related risks of e.g. mortality[12]. In the 1969/70 conscription cohort, the proportion of smokers was similar among normal weight and overweight. However, normal weight individuals were to a greater extent light smokers (1-10 cigarettes per day), while heavy smoking (>10 cigarettes per day) was more common among the overweight.

Data on smoking were retrieved from the Military Service Conscription Register, in which number of cigarettes smoked per day (0, 1-5, 6-10, 11-20 or >20) were registered on an individual level for the 1969/70 conscription cohort. Smoking was categorised into non-smoker, light smoking (1-10 cigarettes per day) and heavy smoking (>10 cigarettes per day).

2.3.4 Muscular strength

Muscular strength was also adjusted for in order to at least partly account for the inherent limitation of BMI of not being able to distinguish muscle from fat mass. Muscular strength was measured at the conscription tests by use of leg extension, arm flexion and hand grip (Newton).

2.3.5 Geographical region

Unemployment and overweight differ by region, and could also be associated with each other. In 1991, the legislation regarding disability pension was changed to exclude the possibility of granting a disability pension based on conditions of the employment market. This indicates that granting a disability pension due to high degree of unemployment in a region may have occurred before 1991. In study II regarding the association between overweight and disability pension, the analyses were adjusted for geographical region. However, this variable had very limited impact on the overweight-related risks.

Data on test center in the Military Service Conscription Register was used to represent geographical region. Conscription tests were conducted in Kristianstad, Göteborg, Stockholm, Karlstad, Östersund and Boden, which are cities spread out over the country, thereby representing the different geographical regions. Young men generally performed the tests in the city closest to their place of residence.

2.3.6 Municipality

The variable “municipality” represented level of urban or rural residency. Municipality could confound the risk of disability pension in the same way as geographical region, since unemployment rates as well as prevalence of overweight may differ between rural and urban areas. In study II regarding the association between overweight and disability pension, the analyses were adjusted for municipality (referred to as "place of residence"). The variable had very limited impact on the overweight-related risks.

Data on municipality were coded into three levels of urban/rural residency (urban, semi-urban and rural), based on the classification of the municipalities of the Swedish Association of Local Authorities and Regions.

2.4 STATISTICAL ANALYSIS

2.4.1 Cox regression

A Cox regression model[57] was employed to estimate overweight-related risks of sick-leave in study I and disability pension in study II. By assuming proportional hazards over time between the characteristics in question, the baseline hazard cancels out in the hazard ratio formula of the Cox regression model. No assumption about distribution of the baseline hazard is therefore needed, which makes the Cox model robust compared to other models.

In study I regarding overweight-related risk of sick-leave, an extension of the Cox model referred to as the Andersen-Gill model[58] was employed in order to consider the nature of sick-leave as an outcome with multiple events for each individual. The assumption of proportional hazards was investigated graphically in study I and II.

2.4.2 Weibull model

For the Markov model employed in study III annual probabilities for an event (death) to occur were needed. The Cox regression model is not suitable for estimation of such probabilities since it only provides information regarding the proportional risk, not how the risk changes over time, e.g. how the mortality risk increases with age. In study III, a Weibull model was employed to obtain the information regarding the absolute mortality risk necessary to develop annual transition probabilities for the Markov model.

The Weibull model is a proportional hazards model based on a distribution which includes a scale parameter as well as a shape parameter. The shape parameter defines how the risk changes over time (age). With these two parameters the Weibull model becomes highly flexible, and generally gives similar results in relative risk estimations as the more commonly used Cox model[59].

2.4.3 Logistic regression

In study II logistic regression was used to estimate future prevalence (probability) of underweight, normal weight, pre-obesity and obesity (all modelled as binary outcomes) among Swedish men. Data from the Military Service Conscription Register from 1969 to 2005 (n = 1.6 million) was used for these analyses.

One model was fitted for each BMI category, where year of military conscription test was included as the only predictor. The future prevalence was then calculated according to the following formula:

$$\text{prevalence} = \frac{e^{(\alpha + \beta \times \text{year})}}{1 + e^{(\alpha + \beta \times \text{year})}}$$

where α is the intercept on the log odds scale and β is the log odds ratio for the BMI category.

2.4.4 Markov model

In study III, a Markov model was employed to investigate the effects on mortality of trends in overweight and smoking. A Markov model consists of mutually exclusive states between which transitions are possible[60]. If the initial distribution over the different states is known, as well as the probabilities of transition between the states, it is possible to predict future state distributions. Markov models are suitable for analyses including changes over time between different states, such as health economic evaluations where future costs and health effects for patient groups are estimated.

The states of a Markov model have no memory, a limitation referred to as the "Markovian assumption". This means that a specific state holds no information about how long individuals have spent in the state, or in which states they have previously resided. This can be overcome by the use of "tunnel states", to which individuals are transferred only by passing through other states. But if the population that is to be simulated is very heterogeneous regarding the transition probabilities between states, a Markov model may eventually be too cumbersome and in these cases an individual sampling model, where each individual is simulated separately, is preferable.

2.4.4.1 The model employed in Study III

For study III, a Markov model was developed to simulate the effects on expected number of premature deaths between age 19y and 56y based on inputs on overweight and smoking. The transition risks were based on survival analysis using Weibull distributions of the 1969/70 conscription cohort as previously described, limiting the time horizon of the model until age 56y if extrapolations outside observed data were to be avoided. The model was constituted by two main health states, "Alive" and "Dead", with possible annual transitions from "Alive" to "Dead". Cycles of one year until cohort participants had reached age 56y or died were used. In each cycle, individuals of the cohort were subjected to time-dependent risks of death, based on overweight, smoking and socio-economic index at age 19y, and age at cycle (i.e. 19-56y, with increasing risk of death with increasing age).

Given cohort simulation and the structure of a Markov model, the state "Alive" was split into several sub-states taking into account four levels of BMI status, three levels of smoking status and four levels of socio-economic index. This resulted in 48 sub-states with specific annual risks of transition to death.

2.4.5 Monte Carlo simulation

Monte Carlo simulations are employed to incorporate the uncertainty associated with the input data in a model[61]. In a Monte Carlo simulation, probability distributions are fitted to the variables, and for each iteration of the simulation the variable values are sampled from these distributions. Each iteration generates a specific set of variable values, which gives a specific result. The set of results from a Monte Carlo simulation can be used to describe parameter uncertainty.

In study III and IV, Monte Carlo simulations were run for 10 000 iterations, and empirical 95% confidence intervals were retrieved from the sorted simulation results as the 250th and 9 750th values.

2.4.6 Population attributable fraction

Population attributable fraction is an estimate of the proportion of cases which would be prevented if a certain exposure was eliminated from a population[62 (p.295)]. This information can often be more useful for public health policies than the commonly reported relative risk (RR), since population attributable fractions also take into account the prevalence of the risk factor. A rare risk factor would have a limited effect on the population level no matter how high the relative risk.

In this thesis, additional analyses of population attributable fractions have been performed regarding percent of cases of sick-leave, disability pension and death which would be prevented had no one among the young men performing military conscription tests in 2004/05 been overweight. These analyses were also performed for light (1-10 daily cigarettes) and heavy (>10 daily cigarettes) smoking, for comparison.

Population attributable fraction is calculated as number of excess cases due to a risk factor divided by the total number of cases (including the excess cases). The resulting proportion represents cases that could have been avoided, had the risk factor not been present. This assumes a causal relationship between the risk factor and the outcome. Based on the methods outlined by Rothman et al[62 (p. 295)], the number of excess cases due to a risk factor can be described as p(RR-1), where p is the prevalence of the risk factor and RR-1 is the relative risk of the outcome minus 1, i.e. the relative effect. The total number of cases is then 1 plus excess cases. In the case of this thesis, with two levels of the risk factor overweight, namely pre-obesity and obesity, population attributable fraction (AF_p) of an outcome was calculated as:

$$AF_p = \frac{p_{po} \times (RR_{po}-1)}{1 + p_{po} \times (RR_{po}-1) + p_{ob} \times (RR_{ob}-1)}$$

for pre-obesity, and

$$AF_p = \frac{p_{ob} \times (RR_{ob}-1)}{1 + p_{po} \times (RR_{po}-1) + p_{ob} \times (RR_{ob}-1)}$$

for obesity, where “ob” stands for obesity and “po” pre-obesity. By summing up the population attributable fractions from pre-obesity and obesity, the total for overweight was achieved. Separate calculations were performed for death and disability pension as well as short-term, intermediate-term and long-term sick-leave episodes, for both pre-obesity and obesity. Among the conscripts 2004/05, 15.6% were overweight and 5.5% were obese. The hazard ratios for the outcomes found in study I, II and III were used as relative risks. Regarding smoking, 15.6% were light smokers and 7.6% heavy smokers in 2004/05. The relative risks of premature death for light and heavy smoking compared to non-smoking were estimated to 1.5 and 2.1, respectively.

Regarding productivity losses, not only the number of cases of a certain outcome is of interest, but also the timing of the cases. Since population attributable fractions do not consider timing of cases, an additional analysis was performed in order to estimate the possible proportional decrease in future productivity losses, had no one of the young men performing military conscription tests in 2004/05 been overweight. This analysis estimated the future productivity losses of the 2004/05 conscription cohort using the following formula:

$$\text{future PL} = p_{uw} \times PL_{uw} + p_{nw} \times PL_{nw} + p_{po} \times PL_{po} + p_{ob} \times PL_{ob}$$

where "PL" is productivity losses , "p" prevalence, , "po" pre-obesity, "ob" obesity, "nw" normal weight and "uw" underweight. First, the future productivity losses with observed prevalences of underweight, normal weight, pre-obesity and obesity (6.1%, 72.9%, 15.6% and 5.5%, respectively) for the 2004/05 conscription cohort were calculated. Then, the corresponding productivity losses were calculated given that no one had been i) pre-obese, ii) obese, iii) neither pre-obese or obese, but instead normal weight. Finally, the future productivity losses of these hypothetical cohorts were compared to the estimated productivity losses of the 2004/05 conscription cohort. Similar calculations were performed regarding smoking as well.

2.4.7 Interaction

When the effect on an outcome of an exposure only appears if another exposure is also present, or when the effect of an exposure varies with the level of another exposure, we are witnessing a phenomenon known as interaction.

The occurrence of interaction between two exposures can depend on the scale chosen to measure the effect, e.g. risk difference or risk ratio. Rothman calls this "statistical interaction" and argues that it differs from "biological interaction", which originates from a biological mechanism and either exists or does not exist, independent of scale[63 (p.171)].

In this thesis, interaction between smoking and overweight was investigated regarding the effect on sick-leave in study I and disability pension in study II. Interaction was measured using the methods outlined by Andersson et al[64]. Based on the Rothman definition of interaction, the relative excess risk due to interaction (RERI) is estimated for multiplicative models using these methods. However, the interaction is not estimated until log transformation has occurred and the model is additive. Possible combinations of the risk factors are coded as dummy variables, in order to achieve relative risk estimates not only for the risk factors (here overweight and smoking), but also for the joint risk factor (overweight + smoking). The relative excess risk due to interaction from overweight and smoking is then calculated as the relative risk of the joint risk factor (overweight + smoking) subtracted with the relative risks of overweight and smoking independently. The formula can be expressed as:

$$RERI = RR_{AB} - RR_A - RR_B + 1$$

where RERI is the relative excess risk due to interaction; RR_{AB} is the relative risk associated with the joint risk factor (overweight + smoking); RR_A the relative risk associated with one of the risk factors and RR_B with the other. 1 is added since the underlying risk, that is the risk for the reference (normal weight non-smoker in this case), is equal to 1 and is included in all the relative risks. It is being subtracted twice in the equation, but since it should be part of the RERI as well, this reference risk is added.

2.5 ESTIMATION OF PRODUCTIVITY LOSSES

Since the human capital approach is the most frequently used and the one recommended by the Swedish pricing and reimbursement agency TLV[65], this method was chosen for the estimations of the productivity losses associated with overweight. The effect on the results of instead using the friction cost method was investigated in an additional analysis.

2.5.1 Human capital approach

For the calculations of the productivity losses using the human capital approach, all work absence from age 19y to 65y (age of retirement) was included. An individual who was granted a disability pension or died at age 60y thus accumulated 5 years of work absence and lost productivity. Extrapolations of the observed data from age 57y to 65y were performed.

The time of work absence was multiplied with the value of the production per time unit. This value was estimated as the gross salary multiplied by the social fees (31.42%, www.skatteverket.se). The same salary for all men was used, but stratification was made regarding age.

Data on average salaries in 2008 were retrieved from Statistics Sweden (www.scb.se) and defined as income from employment, self-employment, pension, sick pay and other taxable incomes, but not income from capital. Unfortunately, statistics for salaries excluding transfers like pensions and sick pays were not available. Salaries were inflated to year 2010 by use of the consumer price index.

2.5.2 Friction cost method

In an additional analysis, the productivity losses were calculated using the friction cost method. With this method, the work absences were truncated after a friction period of six months, which is a general friction period according to Dutch guidelines[66].

No elasticity factor was used, i.e. a factor that considers that colleagues cover up for the sick employee and that some of the lost work is made up for afterwards. The elasticity factor has been suggested to have a value of 0.8[25]. Although not used in study IV of this thesis, this factor can easily be applied afterwards by simply scaling down the resulting productivity losses with a factor of own preference.

The same value of production per time unit as for the human capital approach was employed for the friction cost method.

3 RESULTS

3.1 OVERWEIGHT-RELATED RISK OF WORK ABSENTEEISM

Risks of sick-leave, disability pension and premature death associated with overweight compared to normal weight are shown in **Figure 2.** Overall, the longer the work absenteeism (sick-leave episode, disability pension or premature death), and the higher the degree of overweight, the higher the relative risk.

Pre-obese individuals were found to have 20% increased risk of intermediate and long-term sick-leave episodes compared to normal weight individuals (HR 1.20 ($CI_{95\%}$ 1.15-1.24) and 1.19 ($CI_{95\%}$ 1.15-1.23), respectively), and about 30% increased risk of disability pension and premature death (HR 1.34 ($CI_{95\%}$ 1.19-1.51) and 1.31 ($CI_{95\%}$ 1.15-1.52), respectively).

Obese individuals were found to have 13%-55% elevated risk of sick-leave/disability pension compared to normal weight individuals, depending on the duration of the absence period. The risk of a short-term sick-leave episode was found to be increased by 13% (HR 1.13 ($CI_{95\%}$ 1.09-1.16)), an intermediate or long-term by about 35% (HR 1.35 ($CI_{95\%}$ 1.24-1.47) and (HR 1.34 ($CI_{95\%}$ 1.24-1.46), respectively) and for a disability pension by 55% (HR 1.55 ($CI_{95\%}$ 1.18-2.05)). Obesity was found to be associated with twice as high a mortality risk as normal weight (HR 2.07 ($CI_{95\%}$ 1.56-2.75)).

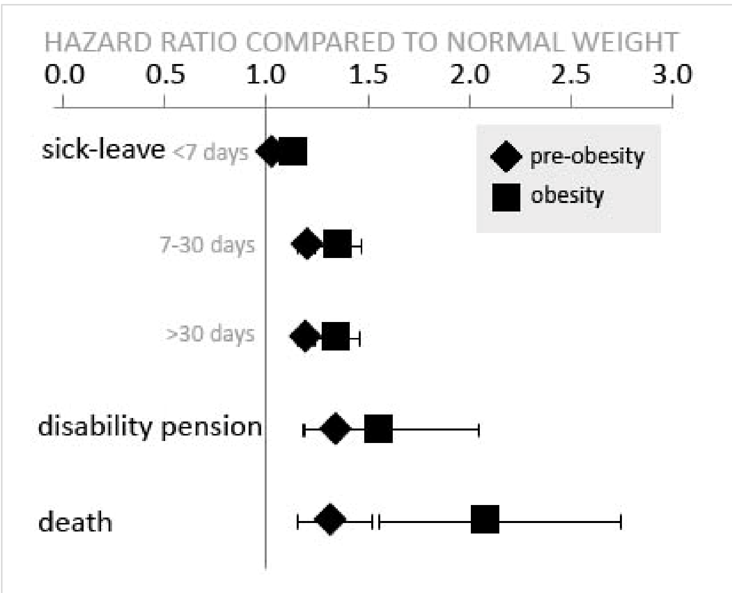

Figure 2 Risk for different kinds of work absenteeism for pre-obesity and obesity compared to normal weight.

No interaction reflecting greater combined effect was detected between the risk factors smoking and overweight regarding work absenteeism*. In some cases a negative interaction was found, that is a lower risk than expected given the presence of both risk factors.

* for analysis of interaction regarding mortality for this cohort see Neovius, M., J. Sundstrom, et al. (2009). "Combined effects of overweight and smoking in late adolescence on subsequent mortality: nationwide cohort study." BMJ **338**: b496

3.2 PRODUCTIVITY LOSSES ASSOCIATED WITH OVERWEIGHT

The lifetime productivity losses associated with normal weight and overweight are shown in **Figure 3**. Using the human capital approach, the lifetime productivity losses (from age 19y to age 65y) to society originating from sick-leave, disability pension and premature death were estimated to €55 570 ($CI_{95\%}$ €50 856 - €61 422) for a normal weight individual. The corresponding productivity losses for a pre-obese and an obese individual were €72 611 ($CI_{95\%}$ €66 345 - €80 722) and €95 441 ($CI_{95\%}$ €88 956 - €102 853), respectively. The lion's part of the productivity losses originated from premature death. 20% of the pre-obese individuals and 15% of the obese who died during follow-up were granted disability pensions prior to death.

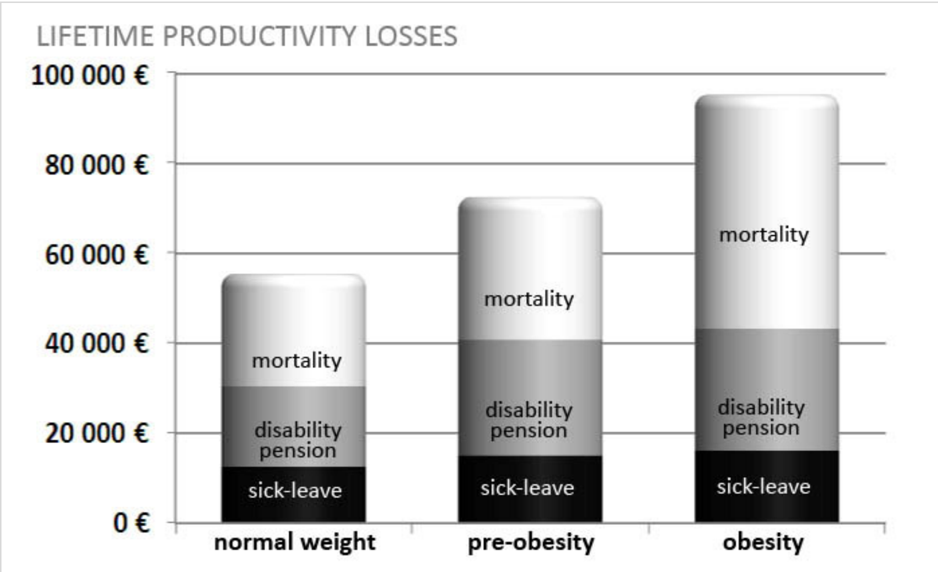

Figure 3 Lifetime productivity losses from sick-leave, disability pension and mortality for a normal weight, pre-obese and obese individual.

3.3 EFFECT OF OVERWEIGHT ON THE POPULATION LEVEL

Despite the fact that the mortality risk associated with obesity was twice as high as for normal-weight, and despite the fact that the prevalence of obesity has quintupled among young Swedish men since 1970, the results indicated that young men today will enjoy a higher life expectancy than young men in the 1970's. This can be explained by significantly improved smoking habits (in 1969/70, 59% of the conscripts were smokers compared to 23% in 2004/05), as well as by the low initial prevalence of obesity in 1969/70 (less than 1%). However, if the obesity epidemic continues along the same course as during the recent decades, the prevalence of obesity was estimated to be 20% among young men in 2030. At that point, the life expectancy was calculated to be reduced to the levels of the early 1970's.

Analyses using population attributable fraction indicated that successful overweight prevention could help to avoid 1-10% of future sick-leave events, disability pensions and premature deaths for the 2004/05 conscription cohort (**Figure 4**). Up to 3% of the future cases of sick-leave and disability pension for the young men performing conscription tests in 2004/05 could be avoided, had no one in the cohort been obese. In the same way, 5% of the mortality cases, the strongest contributor to the productivity losses, could be prevented. The corresponding numbers for pre-obesity were similar. Had no one in the cohort been a smoker, 14% of the mortality cases could have been avoided (7% attributable each to light and heavy smoking).

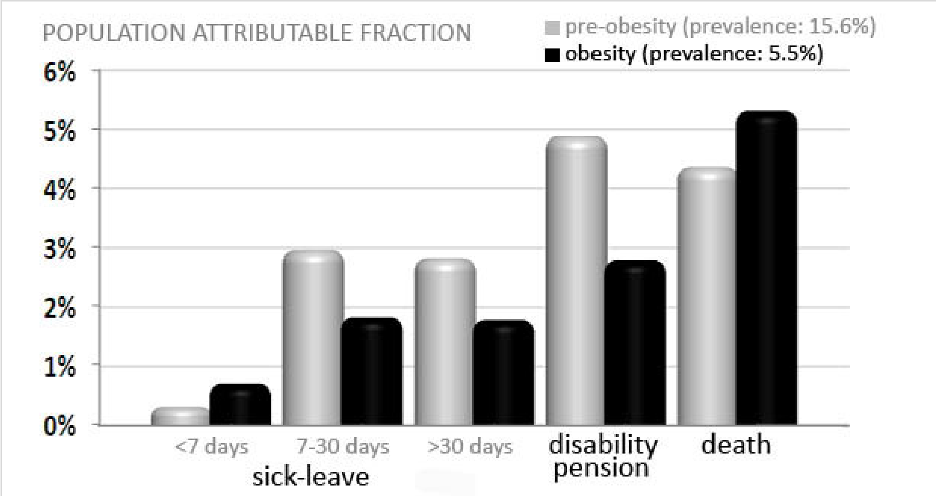

Figure 4 Population attributable fractions regarding sick-leave, disability pension and death for pre-obesity and obesity, given the prevalences in the conscription cohort 2004/05.

An extension of the analysis to also consider timing of the cases indicated that a reduction of 8% in future productivity losses for the 2004/05 cohort could have been achieved, had no one been overweight (4.4% attributable to pre-obesity and 3.6% to obesity). That would correspond to €0.5 billion (n = 94 219). Had no one in the cohort been a smoker, the future productivity losses could have been reduced by 12% (5.7% attributable to light smoking and 6.3% to heavy smoking).

4 DISCUSSION

4.1 MAIN RESULTS

The overall objective of this thesis was to investigate the association between overweight and work absenteeism with its related productivity losses from a societal perspective. Specifically, the objectives were to investigate the association between overweight and risk of sick-leave (study I); to investigate the combined effects of overweight and smoking on subsequent disability pension (study II); to investigate the effect of past and future trends in overweight and smoking on premature mortality (study III); and to estimate the lifetime productivity losses associated with overweight (study IV).

The results showed that both pre-obesity and obesity were associated with increased risks of sick-leave and disability pension. The longer the absenteeism, and the higher the degree of overweight, the higher the relative risk compared to normal weight. Lifetime productivity losses due to sick-leave, disability pension and premature death were estimated using the human capital approach to €73 000 ($CI_{95\%}$ €66 000 - €81 000) for pre-obese individuals and to €95 000 ($CI_{95\%}$ €89 000 - €103 000) for obese individuals, compared to €56 000 ($CI_{95\%}$ €51 000 - €61 000) for normal weight individuals. Premature death was the greatest contributor to the productivity losses.

Overweight and smoking are important risk factors for impaired health independently, but no interaction causing excess risk of sick-leave and disability pension when these risk factors were combined was detected. Instead, the combination of the two risk factors was in some cases associated with lower risk than what would have been expected, given each risk factor's independent contribution to the risk.

Despite the fact that obesity has quintupled among Swedish men since the 1970's, the results in this thesis indicated that young Swedish men today will enjoy a higher life expectancy than corresponding young men in the 1970's, thanks to major decreases in smoking. However, if the prevalence of overweight would continue to increase in the same way as during the past decades, by 2030 the health benefits of the reduced smoking was estimated to be counter-balanced by the health hazards of overweight in Sweden.

Analyses using population attributable fractions showed that between 1-10% of the future cases of sick-leave, disability pension and premature death could have been avoided, depending on outcome, had overweight been successfully prevented for the conscription cohort 2004/05. This would correspond to a reduction of 8% in future productivity losses for this cohort, or €0.5 billion.

4.2 COMPARISON WITH PREVIOUS STUDIES

Overall, regarding the association between overweight and sick-leave/disability pension, the results from this thesis confirmed previous findings indicating that the higher the degree of overweight, and the longer the work absence, the higher the relative risk compared to normal weight[32-43]. It was found that this was valid for the whole population, and not only for specific professions. Furthermore, it was confirmed that the pre-obese category may indeed be subjected to elevated risks for work absence, at least for absences longer than a week.

Overweight has previously been reported to have a more pronounced effect on morbidity than on mortality[7]. In contrast, the results from this thesis found higher relative risks for mortality than for sick-leave or disability pension. A possible explanation could be that sick-leave and disability pension are weak proxies for morbidity, since individuals can suffer from overweight-related morbidity without being on sick-leave or disability pension, and the other way around.

Persson et al. reported the productivity losses associated with overweight in Sweden in 2003 to be more than three times greater than the corresponding health care costs[47]. Comparing the lifetime productivity losses associated with obesity found in this thesis with the corresponding health care costs found in a Dutch study[15] does not result in a similar relation (95 x €1 000 compared to 250 x €1 000; 0.4:1.0). However, these are results from two different countries, and most importantly van Baal et al. used a longitudinal design while Persson et al. used a cross-sectional one, where the composition of the population is important. Therefore this would not be a valid comparison of the relation between health care costs and productivity losses.

Compared to a study by Borg et al.[67], which estimated the excess productivity losses due to premature death for overweight Swedish cohorts from age 30 to 60y and 15y forward, the present study arrived at higher productivity losses. For an obese cohort of men aged 40y, for example, the mean excess lost years of production due to premature death until age 55y was estimated to 0.13 by Borg et al. The corresponding number from the present study was 0.59. No difference in survival between pre-obesity and normal weight was found in the study by Borg et al., which could indicate a situation of reverse causality caused by disease-induced weight-loss, possibly explaining the lower excess mortality for obesity as well. Furthermore, the follow-up period of 15y could be too short for the overweight-related mortality to become manifest.

4.3 CAUSALITY

A couple of circumstances indicate that the associations found in the studies of this thesis between overweight and the outcomes sick-leave, disability pension and premature death are causal. A dose-response relationship was found, with higher risks for the outcomes for increased level of overweight. In addition, overweight was measured in young adulthood, several years to decades before the outcomes occurred, which makes reverse causality improbable (that is that the outcomes caused overweight rather than being caused by overweight).

Furthermore, plausible mechanisms linking overweight to the productivity losses exist. The most prevalent diagnoses for disability pension among the overweight in the 1969/70 cohort were musculo-skeletal disorders, psychiatric disorders and cardiovascular disease. The corresponding most prevalent underlying causes of death were circulatory disease, external factors (e.g. injuries), and tumours.

Cardiovascular disease: A pathological blood lipid profile due to overweight could be a mechanism for cardiovascular disease, supported by evidence that intentional weight-loss through bariatric surgery improved the blood lipid profile[68] and decreased the risk for cardiovascular events[69].

Musculo-skeletal disorders: The physical burden of overweight may exert stress on the musculo-skeletal system, leading to, e.g., knee and back problems.

Cancer: Intentional weight-loss has been shown to lower the risk of cancer, at least among women[70], suggesting a causal link. Although the mechanisms for this link are not completely clear, the promotion of tumour cell growth by overweight-related metabolic abnormalities is a possible candidate.

External factors: Overweight may induce sleep apnoea through, e.g., fat accumulation surrounding the upper airway. Sleep apnoea could lead to increased risk of injuries from, e.g, traffic accidents. Intentional weight-loss has been shown to reduce and even cure obstructive sleep apnoea[71], which supports a causal link.

Psychiatric disorders: Psychiatric disorders may develop as a consequence of overweight-related stigma, but overweight may also be a consequence of psychiatric disorders. Although overweight was measured in young adulthood in the studies of the present thesis, a causal role of psychiatric disorders in the development of overweight rather than the other way around cannot be ruled out.

No diagnoses were available for sick-leave episodes, but one can assume that for longer episodes the diagnoses were similar to those given for disability pension. The underlying causes of shorter episodes are unclear, but it is not impossible that stigmatisation due to negative attitudes towards obese people in working life or the society at large was a contributing factor[72 73].

Intentional weight-loss through bariatric surgery has been shown to improve health through reduced cardiovascular[69] and cancer[70] events, as well as to result in increased survival[74]. Although one would then expect weight-loss to also improve productivity in terms of decreased work absenteeism from sick-leave and disability pension, as a consequence of improved health, the evidence for this is not convincing. In the Swedish Obese Subjects study, a reduction in disability pensions in the surgically treated group compared to the matched controls was found among men, but not among women[75]. However, the absence of improvement in productivity related to disability pension or sick-leave following overweight intervention does not imply that the link between overweight and productivity losses is not causal. It is possible that a return to the labour market after a long period of absence can be difficult to achieve. Also, treatment for other health conditions, which may have been impossible to perform prior to substantial weight-loss, could sustain a seemingly unchanged level of work absenteeism among surgically treated individuals.

4.4 STRENGTHS AND LIMITATIONS

Data source: A strength of this thesis was the use of nationwide register data both for identification of study population and ascertainment of outcomes. This allowed for inclusion of all kinds of professions from all regions of the country in the studies of sick-leave and disability pension, as well as reliable outcome data since these registers serve for administration of economic compensations. Unfortunately, no data source such as the Military Service Conscription Register exists for women in Sweden. Therefore the results of this thesis are restricted to men only. Furthermore, follow-up ended when the age of the cohort was about 56y. Therefore it was necessary to extrapolate the data nine years until age of retirement (65y) in study IV. Extrapolations into the future are always afflicted with uncertainty, but at least the extrapolations in study IV were based on strong data and trends over decades.

Measured BMI: Overweight individuals tend to underestimate their own BMI making self-reported height and weight unreliable[76]. The Military Service Conscription Register contains data on BMI measured by trained professionals, likely resulting in accurate data on BMI. In addition, to have BMI measured at early age when chronic disease is rare, together with a long follow-up period, as in this thesis, helps to avoid reverse causality caused by individuals with illness-related weight-loss and high risks of morbidity and mortality[12].

No repeated measurements: Unfortunately, BMI was measured only at baseline. Although BMI is known to track through life[77-79], the lack of repeated measurements of BMI most probably generated some misclassification. Furthermore, BMI as a measure of overweight has low specificity and sensitivity[54] which also leads to misclassification. These misclassifications can be expected to dilute the true associations between overweight and the outcomes, and cause underestimations.

4.5 POLICY IMPLICATIONS

Decisions regarding overweight prevention/intervention should have a societal perspective and also include consequences other than direct health care costs. A comparison to results from the Netherlands indicates that the lifetime productivity losses associated with obesity could be approximately 40% of the corresponding health care costs[15]. In this thesis it was found that these productivity losses were twice as high for obesity compared to normal weight.

Effective overweight prevention has the potential to substantially decrease productivity losses in society. Obesity was associated with higher risks of sick-leave, disability pension and premature death, as well as with higher productivity losses as a consequence, compared to pre-obesity. However, since the pre-obese are more numerous in the population of young Swedish men, successful prevention of pre-obesity would decrease the total productivity losses in society to a greater extent than successful prevention of obesity (4.4% vs 3.6%). Prevention in society as a whole therefore has the potential to be effective in reducing overweight-related productivity losses, since it would include also the pre-obese.

4.6 DIRECTIONS FOR FUTURE RESEARCH

Other sources of productivity losses: Recommendations for future research in this field includes investigating other sources of productivity losses than sick-leave, disability pension and death which can be associated with overweight, for example the associations of overweight and unemployment, as well as overweight and presenteeism (being at work but not fully productive due to health problems).

Better classification of overweight: Also, studies of the association of overweight and productivity losses with more accurate classification of overweight, for example through repeated measurements during follow-up and better measures of overweight (e.g. waist-circumference), are needed. The existing data may be underestimations due to misclassification.

Longitudinal estimates for women: Women have been found to have higher rates of sick-leave and disability pension than men both in the general population and in patients with chronic disease[80]. Overweight-related productivity losses have been estimated cross-sectionally for women[50], but longitudinal estimates are lacking.

4.7 CONCLUSIONS

Overweight was found to be associated with higher productivity losses compared to normal weight through increased risks of sick-leave, disability pension and premature death. The size of the overweight-related costs from productivity losses was significant, which implies that decision making regarding overweight prevention/intervention should adopt a societal perspective. Effective overweight prevention has the potential to substantially decrease productivity losses in society.

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