Sickness Absence

The importance of socioeconomic status, job strain, iso-strain and effort-reward imbalance

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Titles of manuscripts

The thesis is based on the following manuscripts:

1. Socioeconomic status and duration and pattern of sickness absence.
   A 1-year follow-up study of 2331 hospital employees. BMC Public Health. In press.

2. Job strain, iso-strain and sickness absence.
   A 1-year prospective study of hospital employees.

3. Long term sickness absence: the relation to job strain and effort-reward imbalance.
   A prospective cohort study.

Abbreviations

SES	socioeconomic status
ERI	effort-reward imbalance
SA	sickness absence
BMI	body mass index
RR	rate ratio
OR	odds ratio
HR	hazard ratio
CI	confidence interval
CLL	complementary log-log

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English summary

Sickness absence has received increasing attention through the last decades. Governments have announced a range of measures to reduce sickness absence, and several research projects have aimed to find causes for sickness absence. The relationship between socioeconomic status (SES) and sickness absence is well known; people in lower socioeconomic position have more sickness absence than people in higher position. It is not well known, why these differences exist or if they vary with different characteristicts patterns of sickness absence. Psychosocial work environment has been associated with sickness absence, and many aspects of psychosocial work environment have been investigated. Mainly two stress models are used in this research, the demand-control-support model and the effort-reward imbalance (ERI) model. The central issue in both models is that the combination of certain work environment factors is more harmful than the exposure to the work factors separately. According to the demand-control-support model, high demands are especially harmful in case of simultaneous low control (a situation called job strain); and the situation is further exacerbated in case of coincident low support from colleagues and management, so-called iso-strain. Despite this underlying theory, the model has only seldom been analysed as interactions between the variables. The ERI model combines effort with rewards as a ratio. The association between ERI and sickness absence is only sparsely investigated.

The main aims of the thesis were to examine 1) the association between socioeconomic status (SES) and sickness absence spells of different durations and patterns; and 2) the association between sickness absence and psychosocial work environment, measured according to the ERI model and the demand-control-support model, the latter analysed as strain and iso-strain interactions.

The results of the thesis are based on data from two longitudinal studies with objectively registered sickness absence as outcome. In the first study 2331 employees from a large hospital participated (response rate 84%), and in the second study, the ASUSI study, participated 14.241 persons from a random sample of working persons in Denmark (response rate 70%).

In the hospital study sickness absence was divided into spells of 1-3 days, 4-14 days and >14 days and into groups of no absence, “normal” and “abnormal” absence patterns. Poisson and logistic regression analyses were used to analyse the effects of SES and of strain and iso-strain. The effects of strain and iso-strain were analysed as two-way and three-way interaction terms, controlling for the main effects of demands, control and support. In the ASUSI study the outcome was any absence spell >14 days. Complementary log-log survival analyses were used to analyse the effects of strain and iso-strain, including main and interaction terms as in the hospital study, and of effort-reward imbalance,

overcommitment, and their interaction. Both studies included many covariates to adjust for potential confounders.

The results from the hospital study showed clear socioeconomic differences. Sickness absence increased with decreasing SES. The social gradient was different for the different sickness absence measures; it was strongest for spells of 4-14 days and for "abnormal" absence. The results show the advantages of analysing different durations and frequency of sickness absence. Only general health explained a little of the social gradient.

Results from neither the hospital study nor the ASUSI study supported the hypotheses of the strain or iso-strain interaction in relation to sickness absence. Results from the ASUSI study did not support the theory of effort-reward imbalance according to long term sickness absence, either.

For the demand-control-support model the results are in accordance with existing literature. None of the 6 studies examining the strain interaction and the 4 studies examining the iso-strain interaction in prospective studies found an association with objectively registered sickness absence. Conflicting results were found in the 5 prospective studies examining the ERI model in relation to objectively registered sickness absence. Considering the results of the studies of this thesis and those of previous studies, it is concluded, that the evidence does not support a causal relationship between psychosocial work environment specified by the two stress models and sickness absence.

Dansk resumé

Gennem de seneste årtier har der været tiltagende fokus på sygefravær. Politisk er man kommet med tiltag for at mindske sygefraværet, og videnskabeligt har man søgt at finde årsager til sygefravær. Sammenhængen mellem socioøkonomisk status (SES) og sygefravær er velkendt, folk i lavere socialgrupper har mere sygefravær. Det er ikke velundersøgt, hvorfor der er denne forskel og om sammenhængen er mere nuanceret i forhold til et givent sygefraværsmønster. Psykisk arbejdsmiljø har ligeledes vist sig at have indflydelse på sygefravær, og mange aspekter af arbejdsmiljøet har været undersøgt. Psykisk arbejdsmiljø har især været belyst i forhold til de to fremherskende stress modeller, Karaseks krav-kontrol model og Siegrist' effort-reward imbalance (ERI) model. Det centrale i begge modeller er, at kombinationen af bestemte arbejdsmiljøfaktorer er mere skadelige end arbejdsmiljø-faktorerne hver for sig. Ifølge krav-kontrol modellen er høje krav især skadelige hvis man samtidig har lav kontrol (en situation kaldet job strain), og situationen forværres yderligere ved lav støtte fra kolleger og ledelse (kaldet iso-strain). På trods af denne bagvedliggende teori, er modellen kun sjældent analyseret som interaktioner mellem variablene. I ERI modellen kombineres anstrengelse og belønning som en ratio, og sammenhængen mellem ERI og sygefravær er ikke særlig velundersøgt.

Formålet med denne ph.d afhandling var at undersøge 1) sammenhængen mellem SES og forskellige længder og mønstre af sygefraværsperioder, og 2) sammenhængen mellem sygefravær og psykisk arbejdsmiljø belyst ved hhv. ERI modellen og krav-kontrol modellen, sidstnævnte analyseret som strain og iso-strain interaktioner.

Afhandlingens resultater er baseret på data fra to longitudinelle studier med objektivt registreret sygefravær som udfald. I den ene undersøgelse deltog 2331 ansatte fra et stort hospital (svarprocent 84%). I den anden undersøgelse, ASUSI undersøgelsen, deltog 14.241 personer (70%) fra en tilfældig udtrukket stikprøve af kerne arbejdsstyrken i Danmark.
I hospitalsundersøgelsen blev sygefraværet opdelt i perioder på 1-3 dage, 4-14 dage og > 14 dage og baseret på hyppigheden af disse sygefraværsperioder, desuden i grupper af intet fravær, et 'normalt' og et 'unormalt' fraværsmønster. Poisson og logistiske regressionsanalyser blev brugt til at analysere effekten af SES samt af strain og iso-strain, analyseret som hhv. to-vejs og tre-vejs interaktioner og kontrolleret for hovedeffekter af krav, kontrol og støtte. I ASUSI undersøgelsen var udfaldet sygefraværsperioder >14 dage. Complementary log-log overlevelsesanalyser blev brugt til at analysere effekterne af strain og iso-strain, analyseret som to-vejs og tre-vejs interaktioner samt af ERI, overcommitment og interaktionen mellem disse. I begge undersøgelser blev der kontrolleret for en lang række potentielle confoundere.
Resultaterne af hospitalsundersøgelsen viste klare socioøkonomiske forskelle med stigende sygefravær for faldende social status. Den sociale gradient afhang af sygefraværsmålet, og var således størst for de mellemlange sygefraværsperioder på 4-14 dage og for det 'unormale' sygefraværsmønster. Resultaterne viser fordelene ved at opdele sygefraværet i perioder af forskellig længde og forskellige mønstre. Kun dårligt helbred kunne forklare lidt af den sociale gradient.
Hverken resultaterne fra hospitalsundersøgelsen eller fra ASUSI undersøgelsen kunne støtte hypoteserne om strain og iso-strain interaktioner i forhold til sygefravær. Resultaterne fra ASUSI undersøgelsen kunne heller ikke bekræfte en sammenhæng mellem ERI og længerevarende sygefravær. Resultaterne vedr. krav-kontrol modellen stemmer overens med tidligere undersøgelser. Ingen af de hhv. 6 og 4 prospektive studier som har undersøgt hhv. strain og iso-strain interaktioner i forhold til objektivt registreret sygefravær har været positive. Vedrørende sammenhængen mellem ERI og objektivt registreret sygefravær, så er resultaterne modstridende i de 5 prospektive studier som er publiceret.
På baggrund af denne undersøgelse og af tidligere undersøgelser, konkluderes det, at der således ikke er evidens for at psykisk arbejdsmiljø målt ved de to stress modeller forårsager sygefravær.

Background and introduction

Sickness absence has received much attention in the Danish society in the last years, because it is seen as a major public health and an economic problem. Sickness absence negatively affects colleagues and productivity at the workplace[1] and the society,[2] and it has shown to be predictor of future morbidity,[3] disability pension,[4;5] and mortality.[3;6]

Sickness absence can not and should not be avoided completely. However, if the causes of sickness absence are well known, this can form the basis of prevention of the part of sickness absence that can and should be avoided. So research on reasons for sickness absence is important.

This thesis focuses on the relations between socioeconomic status (SES) and sickness absence, and between psychological work conditions, analysed by the job strain and the effort-reward imbalance models, and sickness absence. Eliminating adverse psychosocial work conditions could be a practicable way of reducing sickness absence. Socioeconomic status can not in the same way be avoided, but more detailed knowledge on the association with sickness absence could be used in prevention.

Sickness absence

Sickness absence, also denoted sick leave or absenteeism, is in this thesis defined as days of absence from work, which the employee attributes to illness. No distinction is made between medically certified absence and self certified absence. Sickness absence is not only interesting if it is due to a medically certified disease. It is an important phenomenon in it self, and it indicates a lack of psychological, social or physical functioning.[7]

On average 5 % of the workforce were absent from work in Denmark in 2006. Compared to other OECD countries, Denmark was placed in the middle with on average 10 sickness absence days per year per employed work force.[8] In Denmark a medical certificate is not mandatory for sickness absence spells, but until recently (2009) the employer could require one for absences >3 days. Employees can normally obtain compensation for up to one year of sickness absence, and in special cases up to a maximum of two years. Mostly, and especially in higher occupational grades, the compensation is equal to the normal salary.

Literature on sickness absence

Since the beginning of the 20th century or earlier, sickness absence has been a topic of research.[9] The amount of available literature on sickness absence is still increasing in medical, sociology, psychology, economics and management disciplines. A search in PubMed on 22 May 2009 retrieved 10.888 references,[a] with 604 references from 1945-1969, 3808 references from 1970-1994, and 6476 references from 1995- May 2009 (respectively 0.21‰, 0.49‰ and 0.79‰ of all the references in PubMed). Half-life of sickness absence articles indexed in Medline is 11 years.[b] As no recent reviews were found concerning the topics of interest for this thesis, the literature have been reviewed on sickness absence studies analysing 1) socioeconomic status, 2) strain and iso-strain and 3) effort-reward imbalance.[a]

Measurement of sickness absence

Many different measures of sickness absence are used.[10] The most common measures are the absence rate, which is the total number of days absent/unit of time, and the absence frequency which is number of absence spells/unit of time. The time unit can be i.e. one calendar year or a more precisely calculated time of risk. These measures do not distinguish between short and long absence spells. The determinants of sickness absence might however differ for spells of different lengths,[11] and analysing the incidence of several durations of spells as outcome may give a more detailed picture of associations with sickness absence.[7] Another way of detailing the association could be to distinguish between different absence patterns defined by both frequency and different durations of spells. However no studies using such absence pattern measures were found.

Socioeconomic status

Socioeconomic status (SES) refers to an individual's relative position in the social hierarchy.[12] SES is most often measured as levels of education, occupation and income.
Socioeconomic inequalities in mortality and morbidity have been widely documented.[13;14] Most often poorer socioeconomic position leads to poorer health and earlier death. The health effects of SES are not only due to the adversities of extreme poverty, but continues at higher levels of SES as well, which have been shown especially by the Whitehall Study as a gradient pattern in mortality.[13;15] Each

[a] See searches in appendix 1
[b] Publication half-time is here defined as the number of years, going back from the current date that account for 50% of the total articles retrieved at the current date.

SES measure, education, occupation and income, shows a clear gradient with health, and are explained by or mediated through the other socioeconomic measures.[16]

The socioeconomic gradient is also present for occupational disability, measured as occupational active life expectancies[17] and for sickness absence.[7;18] In proportion to the frequent use of SES as a covariate in sickness absence studies, rather few studies have examined the causal relationship between SES and sickness absence, and tried to explain the differences.[19]

Table 1 presents the 31 studies found in the literature search on studies examining the association between socioeconomic status and sickness absence. Almost all studies showed that sickness absence increases with decreasing socioeconomic status.[7;18;20-34] Only one study did not find any association.[35] This study examined the association between dichotomised values of education, occupation or income and sickness absence spells above 14 days in women. One study only found an association with occupational groups, and not with education when analysing spells of 1-2 days and spells above 2 days.[23]

Ten studies tried to explain the socioeconomic differences in sickness absence.[18;22;23;25;26;31-34;36] The four studies examining health found that poor health explained some of the differences,[18;25;32;34] and the four studies examining physical work conditions found that this explained some of the differences.[26;31-33] Seven studies examined psychosocial work conditions. Five of these[18;22;26;33;34] found that psychosocial work conditions explained the SES differences, although to a varying degree. Two studies did not separate the effect of psychosocial factors from the effect of other factors.[18;22] In one study psychosocial work conditions explained nothing,[32] and one study found that psychosocial work conditions did not explain anything in men, and hardly explained further of the differences in women, when physical work conditions already had been controlled for.[31] Moreover, gender and groups of other variables analysed together explained some of the differences.[23;36] Although some of the socioeconomic differences in sickness absences may be explained by other factors, a large part of the differences remain unexplained.

The association between SES and sickness absence may differ by the duration of absence spells, but only few studies have examined this problem. Most of the 31 studies used a single sickness absence modality as outcome, e.g. number of absence days, any absence spell, or absence spells of a certain duration.[22;25;27-33] Some studies considered a dichotomy of short and long spells,[18;20;21;23;24] and two studies report associations between socioeconomic status and incidence of sickness absence spells divided into more than two duration categories.[7;26]

Psychosocial work conditions

Psychosocial factors represent the interplay between social (environmental) and psychological (individual) factors.[37] It is difficult to identify adverse psychosocial factors at work because of the variation and differences in exposure and in evaluation of the exposures. The development of theoretical stress models have to some extend enabled the identification. Karasek's job strain model or demand-control-support model[38;39] and Siegrist' effort-reward imbalance model[40] are the most used occupational stress models, based on theories that explain work related psychosocial factors or stressors as reasons for strain and consequently poor health.

The demand-control-support model

The original job strain model, the demand-control model, claims that high demands at work are harmful to health if they are not accompanied by a high level of control or decision latitude. Decision latitude is defined as a combination of decision authority and skill discretion, which is the ability to use ones skills. Job strain occurs when demands are high and control is low, whereas the combination of low damands and high control is the situation with lowest strain. Social support at work is included in an extended model, the demand-control-support model, stating that the greatest risk to health is when exposed to iso-strain (isolated strain), which is high demands in connection with low control and low support.[39] Thus, the interaction between either demands and control, or between demands and control and support is central in the model. However the interaction is not clearly defined.[41] The term 'interaction' is often used in literature on strain when describing combined effects of demands and control. The most common way of analysing the demand-control model has been the 'quadrant term', where employees above the sample median of demands and below the sample median of control are defined as a high strain group. This group is then compared with either the rest of the sample or with a 'low strain' group defined as having demands below the median and control above the median. The combined effect of demands and control has also been analysed as a subtractive form, an additive form, a ratio, and a multiplicative form. The latter is a true interaction when controlled for the main effects of demands and control. The lack of adjustment of the risk estimates for the main effect variables is the most important disadvantage of most ways of defining and analysing strain because significant effects of strain then can be due to the effect of only one of the main variables.
The many different ways of defining strain and iso-strain makes it of course difficult to compare different studies.

Job strain, iso-strain and/or demands, control and support have in many studies shown to have a negative effect on health.[42-45] Most of the sickness absence studies on demand, control and/or support do not analyse the effects of strain and iso-strain, but only the separate effect of three variables. Whereas the importance of demand and support is not clear, job control seems to be a generally accepted predictor of sickness absence.[19;46]

The literature review on strain and iso-strain is shown in table 2. The 22 articles represent 17 studies analysing strain and/or iso-strain in a healthy population with objectively and prospectively registered sickness absence as outcome. The Whitehall II study, the GAZEL study and the Bellstress study published more than one article each.

One of the articles did not report results on strain.[47] In two studies a significant association between strain and sickness absence was found in all adjusted analyses.[48;49] In seven studies no significant effects of strain were found in any of the fully adjusted analyses.[35;50-56] In eigth studies significant effects were found in some but not in other of the adjusted analyses.[57-67] Seven studies analysed iso-strain.[47;49;50;52;55;58;59;61;62;66] Only one of these studies found a significant association with sickness absence.[47;59;61]

Fifteen studies included men, fourteen studies included women, and twelve studies made separate analyses for men and women. Three of the studies including men found significant associations with strain, eight studies found no significant associations, and the results in four studies were either significant or not significant depending on the analyses. Two of the studies including women found significant associations, eight studies found no significant associations, and four studies found both significant and not significant results.

Three studies analysed the incidence of number of absence spells of different lengths, and two of these found a significant effect on short spells (1-5 or 1-7 days), but not on longer spells (>5 or >7 days),[58;62] although one of the studies in another article found a significant association between *increase* in strain and long spells (>7 days), and not with short spells.[63] The third study analysing spells of 1-3 days and of >3 days found no significant associations.[66]

Ten studies defined strain as a high strain group of high demands and low control by dichotomising the sample, either at the median,[35;49;57-65] at the highest quartile[54] or at a certain value according to the wording of the response category.[56] Six studies analysed strain as a multiplicative interaction term including the main effects of demands and control in the analyses.[48;50-52;55;66;68] One study did not define strain clearly.[67] No significant results were found in the studies analysing strain as a multiplicative interaction term.

When the way of analysing strain or iso-strain is not taking into account, the evidence for strain as a predictor of sickness absence is inconclusive. When further considering the possible role of publication or other reporting biases, there may be a large majority of studies with non-significant results.

The effort-reward model

The effort-reward model posits that a lack of reciprocity between effort and potential or expected rewards, an effort-reward imbalance (ERI), leads to emotional distress and other negative health effects. Rewards include money, esteem, promotion prospect and job security. The effect of ERI increases if the person has a certain personality characteristic, so-called overcommitment. ERI was originally defined as a ratio between efforts and rewards above 1.0, and most studies have defined ERI based on a ratio; however the cut point has not always been 1.0, but often defined according to the distribution of the ratio. Few studies have calculated ERI otherwise than a ratio.[69] The interaction with overcommitment is not clearly defined, and is often not included in studies on ERI.
Studies have shown associations between exposure to ERI and poor mental health [43] and coronary heart disease.[70]

The literature review on ERI and sickness absence is shown in table 3. Seven out of eleven studies found that ERI was associated with sickness absence in all or some of their analyses.[49;57;71-75] One study found a non-linear effect of an "intrapersonal equity measure" corresponding to ERI , as a "ERI" score of 1.00 had a lower absence score than both values below and above 1.00.[76] Three studies found no significant association between their ERI measure and sickness absence.[77-79] Only three studies included overcommitment,[49;72;73] two of them with surrogate measures,[49;72] and no significant associations with sickness absence were found. No studies analysed the interaction between ERI and overcommitment.
Eight studies only analysed ERI as a ratio and ERI was defined as either a ratio above 1.0, above the upper quartile, the upper tertile or the median.[49;57;71-74;76;79] Owing to a small study size, one study defined ERI as being present if at least one indicator of high effort and at least one indicator of low reward was significantly associated with sickness absence.[78] One study analysed ERI as a multiplicative interaction term[77] and one study defined ERI in three different ways, as a ratio, as multiplicative interaction term, and as [effort – reward + constant).[75] Consequently, the studies are not all comparable.

Five out of the eleven studies were prospective. Two of these found significant associations in all adjusted analyses; in both studies the outcome was the number of sickness absence spells >3 days.[49;57] One study found associations with number of spells of 1-7 days and >7 days for men, and of 1-7 days for women,[74] but not with spells of >7 days for women. Two prospective studies found no significant associations with respectively any spell >3 days[77] and any absence.[79]
Overall there seem to be an association between ERI and sickness absence. The evidence of a causal relation is inconclusive because of few prospective studies with conflicting results, although it is worth mentioning that all three prospective studies analysing absence frequency (incident number of absence spells) found significant associations with ERI. [49;57;74]

The demand-control-support and the effort-reward models

It has shown up that the demand-control-support model and the effort-reward model may have independent effects when analysed in the same study, when analysing cardiovascular disease[80] or mental health.[81] Only few studies included strain and ERI in the same studies as explaining factors to sickness absence.[49;57;75;77] Three of these studies were prospective, of which two found associations with both ERI and strain and subsequent number of sickness absence spells longer than 3 days during respectively one year,[49] and 2-3 years,[57] whereas the third study found no association with strain or ERI and one or more subsequent spells of more than 3 days during three months.[77] The fourth study analysed the total number of absence days in the year preceding the investigation, and only found an association with ERI.[75]

Other determinants of sickness absence

Many factors influence the risk of sickness absence. Generally higher absence is found among women and in older age groups.[19] The female excess has been found to be gradually weakened with lengthening absence, and to have different explaining factors depending on the length of absence.[82] Increasing age has been found to have a positive longitudinal effect on absence rate and a negative longitudinal effect on absence frequency.[51] Not surprisingly poor health[83] and work ability[64;83] are associated with sickness absence. Although the life style risk factors are part of more complex lifestyle patterns associated with increased health risks, several studies suggest that the risk factors of overweight, smoking and inadequate physical activity contribute toward higher sickness absence, even after controlling for health status and workplace factors.[19] A review found insufficient evidence for an effect of marital status and of children living at home on sickness absence, and limited evidence for

the effect of divorce[19]. Studies have found that having children below 7 years[84] and being single women with children[85] are associated with sickness absence. Work-family conflict have been found to be associated with sickness absence.[84;85] Low control over daily working hours, as well as long domestic working hours, long commuting hours and long total working hours have been associated with increased rates of sickness absence >3 days.[86] Full time/part time work might be related to sickness absence,[87;88] as well as evening and night work.[87;89] Physical work conditions have been found to be associated with sickness absence,[90;91] although a review found limited evidence for an association.[19] Other psychosocial factors than those from the demand-control-support and ERI models have shown associations with sickness absence: role conflict,[92;93] poor management quality,[92;93] bullying,[90] anxiety about reorganisation of the workplace,[90] lack of encouraging and supportive culture,[77] low meaning at work,[93] violence and threats,[93] as well as job satisfaction.[7;91]

Possible pathways

The possible pathways of the associations of SES and psychological work conditions with sickness absence are complicated and far from clear.[94] This is illustrated in figure 1. The boxes in between are of course a simplified way of representing the pathways. All possible boxes/variables, arrows, and interaction effects are not shown and no feedback loops are shown indicating the possible adverse effects of sickness absence. Theoretically, very different risk factors can simultaneously influence the risk of sickness absence.

The overall aims of this thesis are shown by the thick arrows: 1) To examine the associations between SES and sickness absence, and to explain the expected differences according to SES, and 2) to examine the associations between respectively strain and ERI (included in "work factors" in figure 1) and sickness absence.

Specific aims

The specific aims of the thesis were:

1. To examine the relation between socioeconomic status in a large Danish hospital and prospective objectively recorded sickness absence divided into spells of 1-3 days, 4-14 days and more than 14 days, and grouped as a specific sickness absence pattern labelled as 'normal' and 'abnormal'. Further to examine if a large number of potential confounders or mediators could explain the effects of socioeconomic status on sickness absence.

2. To examine the relation between respectively strain and iso-strain, analysed in regression analyses as multiplicative interaction terms, and prospective objectively recorded sickness absence divided into spells of 1-3 days, 4-14 days and more than 14 days, and grouped as an 'abnormal' sickness absence pattern.

3. To study strain, iso-strain, ERI and the interaction of the latter with overcommitment as determinants of prospective objectively recorded sickness absence spells of >14 days in a large prospective Danish study, adjusting for a large number of potential confounders.

Material and Methods

Aim number 1 and 2 are examined in respectively study 1 and 2, based on a study population of employees in a hospital. Aim number 3 is examined in study 3, the ASUSI study, based on a random sample of the working population in Denmark.

The hospital study (study 1 and 2)

The study population consisted of all employees at a general hospital in the county of Copenhagen, including somatic and psychiatric departments and supporting staff. A baseline questionnaire about work conditions, health and personal circumstances was distributed to 3199 employees by departments at the end of October 2000 followed by two reminders. Before 1st of January, 2687 (84%) questionnaires were returned. After exclusion for reasons shown in table 4, the material consists of 2331 questionnaire responders. The participants worked in 28 departments divided into a total of 182 work units, comprising from 1 to 53 persons, the median being 11 persons. The work units were the lowest organisational level of the hospital, typically a ward or ambulatory. Among responders there was a slight underrepresentation of men, of employees aged <30 years and ≥60 years, and the non-responders had slightly more absence than responders. The study was performed to improve work conditions and reduce sickness absence, and the purpose of the study was to supply the hospital and the departments with aggregated systematic information about perceived work conditions, health and sickness absence data. The study was supported by management and employee representatives. Participation was voluntary and only research staff had access to person-related data.

Sickness Absence

Participants were followed through hospital administrative data files from January 1st 2001 until the last date employed in the same working unit or to the end of 2001 whichever came first. Data on absences due to ordinary sickness absence was recorded by frequency and duration categories. The records did not contain information on diagnoses. Data on part time sickness absence was not available.

Days at risk for starting a new spell of sickness absence was calculated as calendar days in the follow-up period, excluding Saturdays, Sundays, holidays, days on vacation, and days of absence due to ordinary sickness, maternity leave, pregnancy related sickness or care of sick child. One day for each sickness absence spell was added since the first day of an absence spell starts as a day at risk.

The incidence rate was defined as all new sickness absence spells during the follow-up period divided by days at risk in the same period. Sickness absence was divided into short spells of 1-3 days, medium spells of 4-14 days and long spells of more than 14 days.
In most sickness absence studies, sickness absence is compared to no absence. However in most cases, it is more 'normal' to be absent during e.g. one year, than not being absent at all. The reference group should then rather be persons with 'normal absence behaviour' including no absence, than only people without absence. This was the reason for defining two groups, one with a 'normal' and the other with an 'abnormal' absence pattern. Abnormal absence was defined as more than two short, one medium or one long spell, and altogether more than three spells of any length during the observation period. Other combinations of absence were considered as 'normal' absence.

Hospital register data

Age and gender were registered in the hospital records. Based on job titles from the hospital register, the personnel was divided into the following 6 occupational groups: 1) doctors, dentists, psychologists and other academic staff, 2) physiotherapists, midwives, medical laboratory technologists, social workers and alike, 3) nurses, 4) medical secretaries, office, and administrative workers, 5) nursing assistants, 6) cleaning personal, hospital porters, and various assistants.
Moreover a variable of 'special duty responsibilities' (yes/no), defined according to the job titles was included in study 2.

Questionnaire data

Information on cohabitation and children at home, regular working hours per week, frequency of duties on evenings/nights, frequency of weekend duties, and overtime work was recorded by questionnaire. Social support from family or friends was measured by a single item and personality characteristics was measured by three single items, covering negative affectivity, type A behaviour and self efficacy.[95;96] General health was measured by a single item from SF36.[97]
Strain and iso-strain were based on measures on demand, control and support from the first edition of the Copenhagen Psychosocial Questionnaire, COPSOQ.[98] (See appendix 2.) An overall job demand scale was constructed by taking the mean of the 3 demand scales, work related quantitative demands, cognitive demands and emotional demands. A control scale was constructed as the mean of the decision authority and the skill discretion scales.

Effort and reward were measured by two single items with 6 verbally anchored response categories. (See appendix 2.) An effort-reward imbalance variable, ERI, was constructed by dividing effort by reward.[40]

Meaning of work (2 items), commitment to the workplace (4 items), predictability (2 items), sense of community (3 items), role-clarity (4 items), quality of leadership (5 items), and role-conflicts (1 item) were measured with scales and items from the first edition of COPSOQ. Threats and violence was measured with a 3 item scale. Single items were used to measure a feeling of not being safe at work (4 verbally anchored response categories), overall job satisfaction, how you feel like going to work and overall degree of physical work demands (6 verbally anchored response categories).

The response categories for all items were assigned numerical values (1, 2, 3 etc.) with higher values indicating poorer work environment (high demands, low control etc.). All scale values were calculated as the mean of item values. If half or more items in a scale were missing, the scale value was set to missing.

Statistical analysis

Absence spells are not normally distributed, as low values are frequently and high values are rarely observed, which is described as a Poisson distribution. Therefore the incident number of absence spells (any spells, short, medium and long spells) was examined in Poisson regression models. However, for Poisson distributed data the variance is equal to the mean, but for sickness absence data the variance is often overdispersed, i.e. the variance is larger than the mean. Therefore a scale parameter was included in the regression model to adjust the standard errors according to the overdispersion. The Poisson distribution is only reasonably if all persons are followed for the same period of time. This was not the case in this study, why the logarithm of days at risk was included as a covariate with a constant regression coefficient equal to 1.[99]

The equation for the models was:

$$\log_e(\text{number of absence spells}) = \log_e(\text{number of days at risk}) + \rho + \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n,$$

where β_1 is the coefficient of the covariate x_1, and ρ is the scale parameter. Rate ratios (RR) describe the effects of the covariates, and are for the covariate x_i calculated as: $RR_i = e^{\beta i}$.

Rate ratios and their 95% confidence intervals (CI) for model covariates were calculated for short, medium, long and any sickness absence spells. For occupational groups the group of doctors was the reference group.

In addition to this, the association between occupational groups and return to work times among participants with any absence spells was examined in study 1. Participants with any medium but no long absence spells were compared to those with only short spells, and participants with any long absence spells to those with only short spells and to those with any medium but no long spells. Odds ratios (OR) and their 95%CI for occupational groups with the group of doctors as reference were calculated.

Occurrence of abnormal absence pattern was examined in logistic regression models. The equation for the models was e.g.: $\text{logit}(\text{probability of abnormal absence pattern}) = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n$.

Odds ratios (OR) describe the effects of the covariates, and are for the covariate x_i calculated as: $OR_i = e^{\beta 1}$. Odds ratios (OR) and their 95% CI for model covariates described the odds of having abnormal absence compared to a reference group. The reference group differed in the two studies. In study 1 the associations of occupational group with 'normal' and 'abnormal' absence versus no absences were examined, and in study 2 the associations between the demand-control-support variables and 'abnormal' absence versus a reference group including 'normal' absence and no absence was examined. (See 'Discussion of material and methods'.)

Persons working in the same units might have unknown factors in common, factors that made them choose to work in the unit and factors due to influences from working in the unit. Multi-level analysis was used to adjust for these contextual similarities within the work units. A random work unit effect was included in all regression analyses, and median rate ratios (MRR) or median odds ratios (MOR) and intraclass correlation coefficients (ICC) were calculated as measures of variance explained by the work units.[100]

The analyses were carried out stepwise, starting with an "empty" model including only the random work unit effect. Subsequent models all included occupational group, gender and age as explaining variables in addition to the work unit random effect. When analysing the incident number of short, medium and long absences, the presence (yes/no) of any other length of absence was included as a covariate in the model to control for the "overlap" between spells of different lengths. (Overlaps are shown in figure 2.) In analyses of absence pattern, 'days at risk' was included as a covariate. For each outcome, a fully adjusted model including all covariates was reduced by backward elimination (the least significant covariates first, if not significant at $p \leq 0.05$) and controlled by forward inclusion. Irrespective of the significance level, occupational groups were kept in the final model in study 1, and demands, control and support were kept the final model in study 2. The interaction terms of strain and iso-strain were only introduced in the final models. If these interaction terms were not significant in the final model, they were eliminated. Strain was analysed as 'demands x control' and iso-strain as

'demands x control x support' and the main variables were always included in these analyses. Demands, control and support are continuous variables with values from 1 to 5. The 'demands x control' interaction term was adjusted to the range of 1-5 by division by 5, and the 'demands x control x support' interaction term was similarly adjusted by division by 25. In this way the relative effect size of a one unit increase of the main and interaction effects are comparable.
It was tested whether associations with occupational group and demand-control-support variables differed by gender by including interaction terms. No significant interactions were found, so separate analyses for men and women were not performed.
In study 1, in the model only including occupational group, gender and age as explaining variables, and the work unit random effect, groups of covariates were introduced separately to see whether the covariates in the group could explain occupational group differences in sickness absence. The groups of covariates were: 1) work related psychosocial variables, 2) work time and schedule variables 3) personal variables and 4) general health.
Analyses were made with PROC GLIMMIX, SAS (9.1).

The ASUSI study (study 3)

The study population consisted of a random sample of 20.481 working Danes. See selection of participants in table 5. To start with, a sample of 30.000 people aged 19-64 years was drawn from the Central Person Register (CPR), which contains unique personal identification numbers assigned to each citizen in Denmark. In autumn 2004, a postal questionnaire was sent to those from the sample who was of Danish origin, having a job and without a high level of previous sickness absence, according to the DREAM database (see below). Two reminders were sent to non-responders. The response rate was 70% or 14.241 persons, who returned a completed questionnaire and belonged to the study population.
Of the responders 50.5 % were men and 49.5 % women. The mean age was 43.7 years (19-64 years). When comparing with official statistics from Statistics Denmark, there was a small underrepresentation of participants below the age of 30 years, of male respondents, of respondents with lower occupational social status and the non-respondents had slightly more absence than respondents.
Data was attained from the questionnaire, from the DREAM database (see below) and from Statistics Denmark. The linkage was carried out by using the Central Person Register.

Sickness absence

The outcome was sickness absence spells longer than 14 calendar days. It was not possibly to analyse spells of shorter duration because the data was obtained from the DREAM register. The DREAM register is a national register on social transfer payment, including sickness absence compensation given to employers.[92] When the study was conducted, employers could apply for this after 2 weeks of sickness absence of an employee, and the register was therefore including sickness absence spells >14 calendar days. The register does not include the exact number of sickness absence days, only weeks with sickness absence. Sickness absence data was obtained from 1st of January 2005 to 31st of June 2006.

The demand-control-support model and the ERI model

The demand, control and support variables were measured with global single items, each with 6 anchored response categories. See items in appendix 2. The single items were validated against the scales measuring the same constructs in the first version of the COPSOQ.[101] The validation study is shown in appendix 3. Correlations between the global single items and the corresponding scales were moderate to high (Spearman correlations from 0.48-0.69). Furthermore correlations were calculated with 33 other variables, of which some were expected to be low (e.g. gender, age, pain) and other were expected to be high (e.g. job satisfaction, quality of management, responsibility at work), and these correlations were generally very similar for the global single items and the corresponding scales. A job control variable was constructed by taking the mean of decision authority and skill discretion, and a support variable was constructed by the mean of the two support single items.

ERI was measured with a short version of the effort-reward questionnaire [102] translated from the English version of the questionnaire. See items in appendix 2. The Danish version was backtranslated to English to confirm the accuracy of the original translation. The short version contains 3 items measuring effort and 7 items measuring reward. The rating procedure consists of two steps. First, participants answer if they agree or disagree to a statement about their work, and if they e.g. agree to a possibly harmful statement, they are asked to indicate whether they are distressed because of the concerned exposure (from "not at all distressed" to "very distressed"). The way of rating is in accordance with earlier and longer versions of the questionnaire, whereas it is different from the published validation study of the short questionnaire.[102] ERI was calculated as the ratio between mean efforts and mean rewards. Overcommitment was measured by a 6 item scale, each with 4 response categories (from completely agree to completely disagree).[102]

Other covariates

Table 6 shows other covariates included in the study.

The response categories for the items were assigned numerical values (1, 2, 3 etc.) with higher values indicating factors supposed to be related to more sickness absence, e.g. poorer work environment. All scale values were calculated as the mean of item values. If half or more items in a scale were missing, the scale value was set to missing.

Statistical analysis

Data were analysed by complementary log-log (CLL) regression for interval-censored survival times where the time variable (week) was included in the model as an indicator variable. The CLL model is a discrete analogue of the continuous proportional hazards model. The outcome was time to the first episode of sickness absence lasting more than 14 calendar days. Risk time was calculated as the time from filling the questionnaire to the week of the first sickness absence period of >14 days, to the week of retirement, death or emigration or to the end of follow-up after 79 weeks, whichever came first. Periods with unemployment were subtracted from the risk time.
The equation for the models was:

$$\log [-\log (1-p_i)] = \alpha(t) + \beta_0 + \beta_{i1}x_1 + \beta_{i2}x_2 \ldots. + \beta_n x_{in},$$

where p_i is the probability of sickness absence in week i, β_{i1} is the coefficient of the covariate x_1 in week i, and $\alpha(t)$ is the time variable. Hazard ratios (HR) and their 95 % confidence interval (CI) were calculated. Hazard ratios (HR) describe the effects of the covariates, and were for the covariate x_i calculated as: $HR_i = e^{\beta i}$.
As the study included many covariates, the analyses were done in two steps. First different models with groups of covariates were analysed to decide which covariates should be included in a full model. The groups were 1) the effort-reward model, 2) the demand-control-support model, 3) socioeconomic status, 4) other work related exposures and 5) personal conditions. Covariates from each group were first excluded by backward selection (the least significant covariates first, if not significant at $p<0.05$). In the resulting model, excluded variables were then re-introduced in the model, one by one, to see if they had a significant effect in this model after correction for multiple comparisons using the Benjamini-Hochberg-procedure.[103] Next, the remaining significant covariates from all the groups were included in a full model and the same procedure of reducing was applied

arriving at a final model with explaining variables with significant independent effects on sickness absence. All models included age and gender. Interactions between demands, control and support was examined by including a multiplicative job strain term, 'demand x control' and iso-strain term, 'demand x control x support' in the model together with the main variables.
Data were analysed with SAS statistical software. The functional form of continuous covariates was assessed with the ASSESS statement in PROC GENMOD and appropriate transformations (eg. log, square-root or exponential) were made if a linear effect was not accepted. Analyses were made with PROC GENMOD using the link CLOGLOG.

Ethics approval

The studies were reported to The Danish Data Protection Agency. According to Danish law, research projects based only on questionnaires do not need permission from an ethics committee.
The participants were informed about retrieval from respectively the hospital register and from the official registers.

Results and Discussion

The hospital study (study 1 and 2)

Among the 2331 participants, 1889 (81%) had at least one sickness absence spell during the follow-up year. Related to the total calculated days at risk, the sickness absence rate was 6.1 %. Many (927 participants) had a combination of sickness absence spells of different duration. These overlaps are illustrated in figure 2.

The sickness absence characteristics in the total sample are shown in table 7. Women and persons reporting fair or poor health had more of all types of absences. 'Normal' absence increased with age and 'abnormal' absence decreased with age. Concerning occupational groups, fewer in the groups of doctors and physiotherapists had absences and generally nursing assistants had most absence. A remarkable result was that the cleaners/porters group had much more absence of medium duration (64%) than the other groups. Any long spells and abnormal absence increased significantly with categories of control and any long spells increased significantly with categories of strain.

To find the covariates with strongest relation to the different sickness absence outcomes, exploratory analyses were conducted without forcing SES or job strain constructs into the final models. The results of these analyses are shown in table 8. The results are not fully in line with those from study 1 and 2 respectively, because the analyses differed slightly: In the exploratory analyses 1) the backward elimination was done in models of subgroups of all covariates, 2) no covariates were forced into the final models, 3) the variable 'special duty responsibilities' was included, contrary to study 1 not including this variable, 4) the interaction terms of strain and iso-strain were not included, contrary to study 1 including the interaction terms, and finally 5) the reference group in the analyses of 'abnormal absence' were people with no 'abnormal absence' whereas it was people with no absence in study 1. (See 'Discussion of material and methods'.)

Most of the significant associations with sickness absence found in the analyses are in accordance with existing literature. Women had more absence of long spells than men,[19] and increasing age was associated with less absence of short spells and less abnormal absence.[51] General health had an effect on all sickness absence outcomes.[83] Short, medium and long absence spells were all risk factors for each other, which is in accordance with the fact that prior absence is an important risk factor for sickness absence.[51] Socioeconomic differences were obvious; this is discussed in study 1. Having no special responsibilities at work was associated with more short and medium spells and with abnormal absence. This variable could be seen as an extra graduation of SES, but similar variables were not

found in other studies. Being single was associated with more short spells and less abnormal absence, and being single with children was associated with less absence of medium spells. The latter is not in accordance with other studies.[85] Getting little social support outside work was associated with less absence. Having full time work was associated with more short spells and more abnormal absence.[88] Poor quality of leadership was associated with more short spells,[92;93] role conflict with more medium spells,[92;93] and violence with more long spells and abnormal absence.[93]

Study 1

For most of the measures of sickness absence the results showed clear differences between the occupational groups. The group of doctors had fewer absence spells and they were of shorter duration than for the other groups, and the groups of cleaners/porters and nursing assistants had more absence spells and spells of longer duration. The remaining groups were in between.

A socioeconomic gradient was obvious for the incidence of medium spells with the highest RR being 4.19 (95%CI 2.84-6.19) for the cleaners/porters and for 'abnormal absence' with an OR of 10.5 (5.30-20.8) for nursing assistants compared to the group of doctors (table 9). For spells of medium and respective long duration compared to spells of short duration the OR for cleaners/porters was 11.2 (6.08-20.8) and 4.71 (1.82-2.19) respectively compared to the group of doctors (table 10). The incidence of long sickness absence spells was not significantly different for the occupational groups. For the incidence of short spells there was a significant difference between the occupational groups but no obvious socioeconomic gradient. Actually, the lowest socioeconomic group, cleaners and porters, had a lower risk of short spells than the highest socioeconomic group of doctors (table 9). This pattern of different socioeconomic associations with sickness absence spells of different duration seems to be explained by the combination of two significant trends: 1) an increase in the incidence of sickness absence spells of any length with decreasing socioeconomic status (table 9), and 2) an increase in the proportion of medium spells and corresponding decrease in the proportion of short spells with decreasing socioeconomic status (table 10).

The socioeconomic gradient was obvious, but some of the results are not strictly hierarchical according to SES. Firstly, the groups of nurses and the group of physiotherapists were considered as having the same socioeconomic status, but the nurses had the highest sickness absence rates in all the analyses. Secondly, the group with most absence was the nursing assistants, and not the cleaners/porters group, whom were considered having the lowest SES. Inequality is likely to relate to relative, rather than to absolute deprivation,[104] and if the SES differences in sickness absence were partly due to the perception of being placed lower hierarchically than others at the workplace, then

this could explain the findings. Nursing assistants are the lowest socioeconomic group in their work units, which is not the case for cleaners and porters, who are working in units with no other occupational groups. Similarly the nurses are working in units with a hierarchical organisation, whereas the personnel in the physiotherapists group is working in their own units.

The high incidence of medium spells in the cleaners/porters group could be due to a common attitude towards absence in this occupational group.

A socioeconomic gradient in sickness absence is in accordance with results from previous studies,[7;18;20-34] but the results are difficult to compare because they were conducted in different countries with different cultures, legislation and compensation systems, and because of different study population characteristics and different measures of socioeconomic status and sickness absence. However similar differences have been shown in Danish studies,[28;31] in hospital studies[23;105] and according occupational groups.[27]

In the present study socioeconomic effects on sickness absence had different patterns for spells of short (1-3 days), medium (4-14 days) and long absence spells (≥14 days), and for 'normal' and 'abnormal' absence versus no absence. These results indicate that sickness absence is a heterogeneous outcome and that sickness absence of different duration or specific patterns of sickness absence may have different determinants. Studies reporting results for short and long absence spells have large variations in cut-points, long absence spells being defined as more than 2 days,[23] 3 days,[21] 7 days[18;20] and 10 days[24] of absence. Thus comparison of results from different studies is difficult for this reason, too. One study that report on 1-3 days and >3 days, categorized as short and long spells, respectively, found no consistent socioeconomic gradient for short spells but a strong gradient for long spells, compatible with our results.[21]

Only very little of the occupational group differences in sickness absence were explained in this study. The risk estimates changed very little from the start model to the final model (table 9).

As expected general health was a consistent, strong and statistically significant risk factor for all aspects of sickness absence. The effects of general health increased with duration of sickness absence spells and with degree of absence pattern (data not shown for normal absence pattern) in accordance with other studies.[7] Furthermore, general health was rated poorer with decreasing socioeconomic status (data not shown). These results are in accordance with other studies.[14;22;106;107] However, occupational group differences in sickness absence diminished only a little when general health was controlled for. After the introduction of general health into the models, most risk estimates was reduced, especially for the incidence of long absence spells and for 'abnormal' absence, especially for the group of cleaners/porters (16% and 17% for the two outcomes, respectively, data not shown).

This could be due to health related selection into occupations or because health acts as a mediator of socioeconomic differences in sickness absence. The results are in accordance with some studies,[25;32] although health explained more of the SES differences in one study.[34] There could be some explications for the lack of importance of the general health measure in the hospital study. People in the different occupational groups could rate their health equally although they had different kinds of diseases with different relations to sickness absence[108]; or they could get sick with different frequencies, without influencing their self rated health. Tasks in some professions in the hospital are impossible to do when having a specific disease, whereas the same disease wouldn't be a hinder in other professions. The fact that cleaners/porters had medium absences rather than short absences could also be explained in relation to different kind of diseases in the occupational groups.

The occupational group differences were not explained by work related psychosocial factors. The introduction of work-related psychosocial variables did not reduce the differences in risk estimates between the occupational groups. On the contrary, they tended to increase the differences, especially for the incidence of medium and long spells and for 'abnormal' absence (data not shown). The results are in accordance with some[31;32] but not with other studies.[26;33;34]

Study 2

No support was found for the hypothesis that sickness absence increases with increasing work stressors in terms of demands, control and support at work, or that the simultaneous presence of these factors have an especially strong effect on sickness absence.

There were no significant interactions in the analyses of all spells, long spells and abnormal absence (table 11). There was a significant three-way interaction between demands, control and support for short spells and a significant two-way interaction between demands and control for medium spells. When these interactions were taken into account, the main effect of support changed direction in the analyses of short spells, and the main effects of demands and control changed direction in the analyses of medium spells, indicating rather complex interactions. The interactions are illustrated in figure 3 and 4. The figures are based on risk estimates calculated from the effect estimates of the final models (table 11) and adjusted relative to an effect of RR=1 for the lowest level of demands and the highest level of control, and in figure 4 also for the highest level of support. According to the job strain and iso-strain hypotheses this level would result in the lowest level of work-related stress and stress-related outcomes.[109] Consequently, the risk of sickness absence should increase from this level by increasing demands, decreasing control and decreasing support. As shown in figure 3 and 4, the

pattern of risk estimates of combined effects of the demand control and support variables was not in accordance with these expectations.

Among the studies analysing strain as the combined effect of demands and control without considering any interaction effects,[35;49;57-65] one study found no significant association between their strain measure and sickness absence[35]; two studies found significant associations,[49;57] and for five studies the results varied by type of sickness absence, gender or other stratification variables.[58-65] Out of the two studies examining iso-strain as the combined effect of demands, control and support and without considering any interaction effects,[47;59;61;62] one study found an effect of iso-strain.[47;59;61] Prospective studies examining true interactions effects of strain[48;50-52;55;66;68] and iso-strain[49;50;52;66] found no significant effects, and the present study are in accordance with these studies.

Study 3

Eleven percent (1571 persons) had at least one sickness absence spell of >14 days. Sixty-nine percent of the population was followed during all the 79 weeks, and 20% were censored during the follow-up time due to other reasons than sickness absence. Thirteen percent of women had a sickness absence spell >14 days, and 9.2 % of men. There were significant differences between the age groups, with increasing sickness absence with older age. However, the group of 60-64 years old had less absence than the 40-49 years and the 50-59 years, probably owing to a healthy worker effect related to early retirement benefits from the year of 60. For all measures of socioeconomic status, there were significant trends indicating that lower social groups had more absence.

The distribution of sickness absence according to the demand-control-support and ERI models is shown in table 12. There were highly significant trends for all associations. Few persons reported very low demands, very low or very high strain and iso-strain, and very low reward and high ERI. The functional form of the relations between sickness absence and the demand-control-support and ERI variables were accepted as linear except for ERI, see below.

The iso-strain interaction term had a significant effect on sickness absence (table 13). Thus, the effects of combinations of different levels of demands, control and support were significantly different. The variation in effects is shown in figure 5. At high social support, a clear interaction pattern compatible with that of the strain hypothesis was seen for the combination of demands and control. However this pattern disappeared as social support became poorer and was even slightly reversed at the poorest level of support. This combined response pattern is not in accordance with the demand-control-support model.

Several studies analysed strain or iso-strain as the combined effect of demands and control (and support) without considering any interaction effects, and with long sickness absence spells (here defined as spells >7 days) as outcome. Some of these found significant effects of strain,[59;61;63-65] although more studies included analyses that did not support the strain hypothesis[35;54;56;59;61-65]; and one study found a significant effect of iso- strain.[47;59;61]
No prospective studies with objectively registered, long sickness absence spells (here defined as spells >7 days) as outcome analysed strain or iso-strain as multiplicative interactions.

The effect of ERI was modelled by a linear and a quadratic term due to a non-linear relationship between ERI and sickness absence. The combined effect of the linear and quadratic term increased until ERI = 2.6 and then decreased to approximately the same low level as for the lowest values of ERI. This pattern was consistent and significant in all models. This was also the case in analyses including all potential confounders in the final model, and whether demand-control-support variables were included in the model or not. This response pattern is not in accordance with the ERI model. There was no significant effect of overcommitment and no significant interaction between ERI and overcommitment. (Table 13.)
Only one prospective study was found examining the effects of ERI on long absence spells (here defined as spells >7 days).[74] This study found an increased risk of sickness absence with increasing ERI, but only for men. The effect of overcommitment was not examined.

The results for the demand-control-support variables in the final model changed only marginally if the ERI variables were excluded and vice versa (data not shown), and the effects of the two models therefore seem to be independent.

The iso-strain effect and the effect of the squared term of ERI were quite consistent and statistically significant in different models, but the p-values were not very low after adjustments in the final model. Considering the size of the study, the effect of iso-strain and the squared ERI term could be due to chance. Therefore the effects of job strain (demands x control) were also examined in models without the iso-strain term. There were no significant effects of job strain in these models. The ERI model terms were further substituted with effort and rewards. For both of these variables a linear relation to sickness absence had been accepted. In a final model including the demand-control-support variables without interaction terms, and effort and rewards, there were small significant effects of

demands, effort and rewards (data not shown). There was no interaction between effort and rewards and no interactions with overcommitment.

Table 14 shows the covariates remaining in the final reduced model. The results are mainly in accordance with the existing literature. Women had more absence of long spells than men,[19] and the age group of 50-69 years had significantly more absence than the reference group of 18-29 years old.[19] Increasing poor health and increasing number of visits to a doctor were associated with increasing absence.[83] Smoking and high BMI were associated with more absence.[19] Increasing somatisation was associated with increasing absence, but contrary to what expected increasing negative affectivity was associated with decreasing absence. Socioeconomic gradients were found for occupational class (Eriksson-Goldthorpe-Portocarero classes) and household income per adult.[7;18] Increasing population density was associated with increasing absence. Being single with children was associated with more absence,[85] and taking care of children was associated with less absence. Finally physical strained work was associated with more sickness absence.[90;91]

Discussion of materials and methods

Design

As most other sickness absence studies, the hospital study and the ASUSI study were observational studies and they were both conducted as prospective analytic studies with varying follow-up time. A longitudinal design makes causal interpretation more plausible, although it does not exclude the possibility of reverse causation. The studies were not true incidence studies as they included participants with previous sickness absence. An optimal design of an observational study would be a cohort study of people in different SES groups and with large variations in psychosocial work environment, taking in people when they started their working life and with repeated questionnaire surveys measuring all possible confounding and intermediate factors and with continually registered sickness absence, including the medical causes for each absence spell. In this way the nuanced picture of sickness absence patterns could be detected together with the causal directions and pathways as those shown in figure 1. E.g. risk factors may differ for different sickness absence spells and each sickness absence spell may have many causes. Patterns of sickness absence can only be detected over a long period of follow-up.[51] However such a cohort study would be very comprehensive and expensive, and hardly realistic.

Selection bias

The target group in the hospital study was all employees in the hospital. Sixteen percent did not respond to the questionnaire. Lower participation in epidemiologic surveys may be associated with lower SES and with sickness absence.[110] But due to the high response rate and to the non-response analysis showing only slightly more absence among non-responders, it is unlikely that selection bias could distort the results.

Because of the random selection of the sample in the ASUSI study, the sample is considered to be representive of the target group, which was the core working force in Denmark. Thirty percent did not respond to the questionnaire. If the sickness absence of non-responders was due to strain, iso-strain or ERI, then the effects of these variables on sickness absence would have been underestimated. It is however unlikely that non-response bias could seriously distort the pattern of effect estimates and interpretation of the results due to the same reasons as in the hospital study, even though the response rate was lower.

In both studies a healthy worker selection due to the fact that persons with bad health may have avoided specific jobs with high exposure to e.g. strain or changed to jobs with lower exposure, may have resulted in an underestimation of associations between respectively strain, iso-strain and ERI and sickness absence.

Information bias

Sickness absence

In both studies an objective measure of sickness absence was used. Neither the hospital administrative data files, nor the DREAM database have been validated, but missing registration has economic consequences in both registers and they are therefore believed to be complete and without serious errors. Obviously, objective sickness absence data are more valid than subjective data, at least if the recall period is longer than a few months.[111] Moreover, by using objectively registered sickness absence, problems due to recall bias and to common method variance are in most cases avoided. The latter could be a problem in sickness absence studies even when the explaining variables and the outcome are not measured by the same method, in the case where a personality trait acts systematically so the tendency to report poor psychosocial work environment at baseline is affected in the same direction as the decision of being absent from work at follow-up. Then the association between psychosocial work environment and sickness absence would be overestimated. To avoid this differential information bias, a measure of negative affectivity was included in both studies, but surprisingly this personality trait was associated with less absence in the ASUSI study.

Sickness absence was measured in up to 1 year in the hospital study and up to 1½ year in the ASUSI study. To detect different patterns of sickness absence and to be able to differentiate between a shorter period of sickness absences and continually frequent sickness absence, a follow-up time of several years would be suitable.[112;113] However when studying psychosocial work environment the follow-up time should not be too long because the work environment most likely will change with time.

In the hospital study the number of absence spells was analysed in relation to days at risk of a new absence spell. Days at risk was precisely calculated. However, no information was available on the specific dates of planned work, only on the number of work days. This could be a problem, especially in a hospital setting where extended duties and night duties may be compensated by more days off and

consequently fewer days at risk than we have calculated. This problem probably only affected a small proportion of persons and planned workdays and do not distort the results in a certain direction.

The study aimed to supply the different hospital departments with group level information on the work environment and sickness absence in order to improve the work environment and reduce sickness absence. Few interventions were carried out late in the follow-up year, and it is unlikely that these activities could have influenced the sickness absence behaviour in the follow-up period.

The division of sickness absence into spells of short, medium and long duration in the hospital study resulted in a more detailed measure than the more common measures of absence rates and absence frequency, not considering durations. The sickness absence data were administratively grouped and it was not possible to split up spells at 7 and 21 days, which would have made the results comparable with more studies.[7;26] Objective sickness absence data is rarely made for research purposes and therefore a standard definition of lengths of absence spells as "short", "medium" and "long" is unfortunately difficult to obtain. However, international standards for cut-points between short, medium and long absence spells would facilitate comparisons between studies.[11]
There was a large "overlap" between sickness absence spells of different duration. To disentangle risk factors for sickness absence spells of a certain duration from those of "overlapping" spells of different durations, the effects of the latter absence type must be controlled for in the analyses. Only two other sickness absence studies addressing this problem were found.[7;78]

In the hospital study, the construct of abnormal absence showed a strong socioeconomic gradient justifying the approach of a different interpretation of combinations of absences of different frequency and duration. However abnormal absence was not associated with strain or iso-strain.
The first intention was to collapse no absences and 'normal' absence to serve as a 'normal' reference group to 'abnormal' absence. But when exploring 'normal' absence, it showed distinct patterns of associations to age, gender, general health and occupational group that were different from those of no absence and 'abnormal' absence (table 7). This was the reason for reporting the results for 'normal' absence without collapsing this group with the group with no absences in the SES analyses of the hospital study. The assumptions about a 'normal' absence were partly met since the socioeconomic gradient for 'normal' absence was much less pronounced than for 'abnormal' absence (table 9). There was also an effect of general health on 'normal' sickness absence, but much weaker than for 'abnormal' absence (data not shown).

The definition of abnormal sickness absence was based solely on a subjective opinion of what is normal and what is abnormal. The definition was made before analysing the data and alternative definitions were not explored. Thirty-nine percent of the participants had 'abnormal' absence and 61 % had a 'normal' pattern including no absence. With these definitions the abnormal group is the smallest and the grouping makes sense. However when the group with no absence is separated out, 42 % had normal absence and 19 % had no absence during the follow-up year, and this still leaves the group with no absence smaller and though as more abnormal than the group defined as having abnormal absence. The solution could be a definition of more than three strata of absence pattern, either according to the distribution of sickness absence in the study group, or as predetermined groups. In both cases the group with no absence could be a reference group and the group with the most absence would then actually be 'abnormal' compared to the remaining group and further not a bigger group than the reference group. Perhaps such a more extreme definition of abnormal absence would have been associated with psychosocial work environment.
The definitions of sickness absence patterns could possibly give more insight into the causes of sickness absence, when examining other explaining variables, too.
An advantage of the construct of abnormal absence is that it solves the problem of large overlaps between sickness absence spells of different lengths (figure 2).

It was not possible to distinguish between self certified and medically certified absence, as do many other sickness absence studies, because this is not distinguished in Danish workplace registers. Usually it is argued that medically certified absence is a more reliable measure because the absence then surely is due to illness. However, as mentioned in the introduction, sickness absence should be regarded as a measure on its own, and not only as a measure of illness. Sickness absence might have consequences what ever it is due to "true illness" or not.

Psychosocial work conditions

In the hospital and the ASUSI study the exposure assessment was based on point estimates, and when the duration of exposures is not measured it is impossible to distinguish people exposed in a shorter period from those with longstanding exposure. This could have lead to underestimation of the association between psychosocial work environment and sickness absence. A possible change of exposure during the follow-up time was to some extent accounted for in the hospital study by limiting the measurement of sickness absence to the work unit where the participants worked when they completed the questionnaire, and to a follow-up time of maximally one year.

As in the hospital and the ASUSI study, most other studies on psychosocial work conditions rely on subjective assessments. Subjective assessments can reflect true environmental conditions, as well as individual's subjective perception and evaluation of the 'true' environment. More 'objective' measurements are external assessment of work environment in specific occupations (based on subjective ratings of the external rater) or exposure matrices or aggregate data based on averages of subjective assessments in specific occupations. If "the variable of interest ... is the work environment, not the experience of the individual"[114], then such 'objective' measures should be preferred. However, the methods are not true objective measures and they capture less of the individual's objective work environment,[115] which is problematic because the variation of work environment could be within occupations rather than between occupations.[116] Moreover, the most important argument for self-reports could be that a certain factor in the work environment could be a stressor for one person and not for another, and this can only be detected by subjective measurements.

Both studies included scales from well validated questionnaires, as well as single global items validated against these scales. It is believed that these measurements generally capture what they were intended to capture. However they may not measure exactly the same as measurements from other of the many available questionnaires[117] as different items and scales capture different aspects of the same psychosocial construct they are intended to measure. Therefore international comparisons are complicated.

Differential misclassification can occur in some cases. Cognitive demands may not be a stressor to all people and may even have a positive effect, which could have underestimated the association with sickness absence.
Control was defined as a combination of skill discretion and decision authority which are in fact different constructs and should perhaps be analysed separately.[52] One study found that high skill discretion predicted spells of 1-10 working days in women, whereas low decision authority predicted spells of >10 working days among men and women,[11] so it is not possible to say in which direction the results could have been biased.
The results could have been biased if some important kind of demands, control, support, efforts or rewards were not captured by the items and scales. An advantage of the global single items is that they encompass this problem by letting the respondent include all kind of e.g. relevant demands because no specific demands are pointed out.

One reason for not finding an interaction effect could be due to the kind of demands and control included in the analyses. It has been argued that different aspects of control may interact with different types of demands, and the type of demands and control should be theoretically likely to interact.[118] The aim of the hospital and ASUSI studies was however to look at the overall demands and overall control according to the model.

Erroneous categorization of strain and iso-strain can lead to misclassification as well. This is in fact a serious problem in most studies on strain and iso-strain. When job strain is defined by the frequent 'quadrant term' it becomes a relative size and will obviously not express real strain in populations where high demands or low control are rare. In the hospital study only 3.3% matched the definition of strain according to meaningful cut-points of demands and control (the wording corresponding to *having often or always/ to a large or very large extent* demands combined with having *seldom, never or hardly ever/to a small or very small extent* control), whereas 23% were exposed to strain based on the median split. In the same way 1.8% had iso-strain according to the response categories, but 17% when calculated by the median split. The same low percentage of 'real' strain have been found in a large Danish study.[119] Moreover 'job strain' defined by the median split do not necessarily mean the same in different populations, and studies are then impossible to compare. Only very few studies mention this problem,[26], indicate the median of the distribution[120] or define meaningful thresholds.[56]

As mentioned in the introduction, most definitions of strain, including the 'quadrant term' cannot distinguish between an interaction effect and separate independent effects of demands and control. In some cases it is obvious when looking at the study results,[59] but few studies mention this problem.[61]

A combination of effects as the ERI ratio is in fact difficult to understand. ERI changes proportionally with effort, whereas the change of ERI increases as reward decreases. The combination of effort and reward have in some studies been analysed as a true interaction.[75] This was also done in the ASUSI study in secondary analyses, but an interaction did not show any effect on sickness absence.

SES

When measuring SES, it is recommended to use different and repeated SES measures.[121;122] In the hospital study SES was only measured once and only with one measure. Moreover the occupational group classification and ordering was based on common knowledge, not on specific personal data except job title. However, occupational groups in a hospital based on titles are somehow hierarchical and reflect other measures of SES, as education and individual income follow the occupational groups. Normally hospital personnel do not change between these occupational groups, therefore repeated measures should not be necessary. But including other measures as spouse's education, household income and parents' education and income would have made the grouping of SES more precise and could possibly have explained SES differences within each occupational group, as a more precise measure perhaps would have revealed even more hierachical results.
Sickness absence in working populations can not be compared with sickness 'absence' among people not belonging to the work force. The SES differences in sickness would certainly have been larger if the target population had been all the adult population, but this was not the purpose of the study.

Confounding and interaction

As shown in figure 1 many possible confounders and mediators exist in the pathways from respectively SES and stressors to sickness absence. Both studies included a large number of covariates to take account for potential confounders. The covariates included were either known as confounders or proxi measures of possible unknown confounding factors, as SES, gender and age. The choice of covariates must be well-considered, to avoid underadjustment as well as overadjustment. When adjusting for covariates, the results explain the differences between the groups that would have existed, in case the distribution of all other factors (the covariates included as potential confounders) were equal. But when adjusting, a correction of the explaining variables can occur if they follow the distribution of the adjusting factors. In this way it has been claimed that adjustment for SES may be overadjustment for effects of the demand-control-support variables, particularly so for control.[114] However SES is an indicator of much more than lack of control at work, and much of the socioeconomic variation in sickness absence remain unexplained. So controlling for SES is a way to control for some of the unknown covariates and for this reason SES was included as a proxi measure of potential confounders. It has been suggested that the true associations between the demand-control-support variables and health outcomes may be between the unadjusted and adjusted results.[62] However in the hospital study SES was only weakly associated with the demand-control-support variables.

Adjustment for some covariates may constitute overadjustment and thus lead to underestimation of the effects, because these covariates may be part of the causal pathway between the exposure and sickness absence. Overadjustment was checked for in the final models by excluding job satisfaction and general health in both studies, and in ASUSI study moreover by excluding visits to a doctor, BMI and smoking, but the results were approximately the same (data not shown).

Not including confounding factors may constitute underadjustment and thus lead to overestimation of the effects, because these covariates could have explained some of the variance in sickness absence. Possible confounders that were not included in the hospital study were life style factors as smoking, alcohol consumption, physical exercise and BMI, specific physical work loads, attitude towards absence and prior sickness absence. In the ASUSI study prior absence could have been a confounder, as well.

In the hospital study life style factors might have explained some of the SES differences in sickness absence. Not including life style factors might have overestimated the effects of strain and iso strain, but as no effects were found, the inclusion would probably not have changed the results.

The hospital study included only a measure of an overall degree of physical work demands measured by a single item. By measuring more specific physical work loads this could have explained some of the SES differences in sickness absence.[123;124] The effects of strain and iso-strain might have been overestimated by not including a more specific measure, [31] but as no effects were found, the inclusion would probably not have changed the results.

Including a measure of attitude towards absence could possibly have explained some of the SES differences in sickness absence, especially the high incidence of medium spells among the groups of cleaners/porters.

Prior absence predicts future sickness absence[51] and as sickness absence might be associated with SES, strain, iso-strain and ERI, it could act as a confounder. As no effects were found concerning strain, iso-strain and ERI, the inclusion would probably not have changed these results, but including previous sickness absence could have diminished the effects of SES. However prior absence was not included in the analyses in the two studies because all the explaining variables also could have been the reason for previous absence, so an adjustment would have been the same as adjusting for the factor of interest.

Although many psychosocial factors were included as covariates in the hospital study, including other variables might have explained some of the SES differences in sickness absence.[34]

Most sickness absence studies make separate analyses for men and women, and many studies have found different results for men and women. In the hospital study and in the ASUSI study analyses were performed including interaction terms between gender and the explaining variables. No convincing evidence was found indicating that the data should be analysed separately for men and women.

Other possible interactions than those included in the analyses may exist. This could be interactions between working conditions and SES[125] or between different specific working conditions.

Generalisation

Both studies included men and women, all adult age groups and a wide spectrum of SES groups. The psychosocial exposures ranged from low to high, although few people were in the extreme categories. It is unlikely that the psychosocial work environment has changed considerably since the two surveys.

The results from the hospital study can possibly be generalised to other municipal hospitals in Denmark. The fact that different absence patterns were found according to different occupational groups in the hospital study might also exist within other municipal workplaces than hospitals, in other parts of Denmark and in other countries. Some diseases[126] and sickness absence[28] are more common in health professions. Sickness absence might be more common in the municipal than in the private sector,[127] so perhaps the differences would be smaller in other professions and in the private sector. In other countries, the differences may be more important, because of larger differences in income and more inhabitants with low income. Different national sickness absence regulations and compensation systems may also affect the generalisability of the results. However, similar differences in sickness absence might exist between occupational groups in other occupational sectors and in other countries.

Causality

As shown in figure 1 several pathways are theoretically possible between SES and sickness absence. As all other variables than sickness absence were measured at the same time, causal relations between these variables cannot be estimated. Reversed causation might exist in the association of SES with sickness absence, but it is unlikely that it applies for an essential part of the study population. Thus the relation between SES and sickness absence is believed to be causal.

Reviews

Even in very sensitive and correctly conducted database searches, only a part of the relevant references are identified, and therefore all relevant published studies have certainly not been found. Additionally many studies are not published, or only published in local languages. Cross-sectional studies were not included in the review on strain and iso-strain because they were not expected to provide information on causal relationship. Objective sickness absence data was another inclusion criteria in this review, although some prospective studies with self reported sickness absence might have a valid absence measure because the recall time was short.[77] No other criteria according to the quality of the studies were applied in order to include as many studies as possibly. Other studies would have been excluded from the review if more criteria of quality had been applied, e.g. according to the description of the study or to the response rate.[67] The inclusion of these studies does not affect the conclusions of the reviews.

It would not have been possibly to make meta-analyses on the studies reviewed because of different study population characteristics, different measures of sickness absence, different measures of socioeconomic status, different definitions of strain and iso-strain, and different confounding factors included in the studies.

Strengths of the studies

The hospital study and the ASUSI study are considered as high quality studies. Although bias may occur in the two studies, the results are believed to be valid. They were prospective, and sickness absence was objectively recorded and is assumed to be precise. The studies had high response rates. The demand-control-support and ERI variables were analysed as continuous variables, the analyses included multiplicative interactions between demands, control and support and between ERI and overcommitment, and adjustment for effects of several potential confounders. The design and data collection of the hospital study aimed at a generally constant work environment during the follow-up period, and the study analysed different sickness absence measures as outcome. The ASUSI study examined a large cohort representative of the Danish core working force with a large variety of occupations, and included the two stress models in the same study.

Conclusions

In accordance with other studies, clear differences in sickness absence were found between the occupational groups in the hospital study. A strong socioeconomic gradient was found for the incidence of medium spells and 'abnormal' absence; and for persons with sickness absences the proportion of medium spells increased and the proportion of short spells decreased with decreasing socioeconomic status. Thus, socioeconomic status was differently related to sickness absence of different duration and pattern.
General health explained very little of the association between sickness absence and socioeconomic status. According to the literature, a large part of the SES differences in sickness absence remain unexplained.

Based on systematic literature reviews and on the present studies, no evidence was found for a support of the demand-control-support model and the ERI model in relation to sickness absence.
The results from the hospital study and from the ASUSI study were not in accordance with predictions of interactions in the demand-control-support model, regardless of absence duration and pattern. The results are consistent with the results of other similar prospective studies, although no published studies examined the causal relationship between the demand-control-support model and sickness absence spells of >7 days.
The results from the ASUSI study did not support the ERI model according to long term sickness absence.
The evidence of a causal relation between ERI and sickness absence is inconclusive because of few prospective studies with conflicting results.

Future studies should take into account the advantage of analysing several different sickness absence outcomes as spells of different duration or combinations of duration and frequency.
Studies examining the demand-control-support model should analyse the combination of effects as true interactions. If there are no interactions then demands, control and support should be included as separate variables and not as combined constructs.
Qualitative studies on e.g. reasons for certain sickness absence patterns, and follow-up studies with several repeated measures should scrutinize through which pathways SES acts on sickness absence. Only with more detailed knowledge, focused prevention strategies could be developed for certain occupational groups.

Figures and tables

Figure 1.
Possible pathways between socioeconomic status (SES), work factors and sickness absence with references above the arrows. (One arrow goes directly from SES to Health, part of this is shown as a dotted line.)

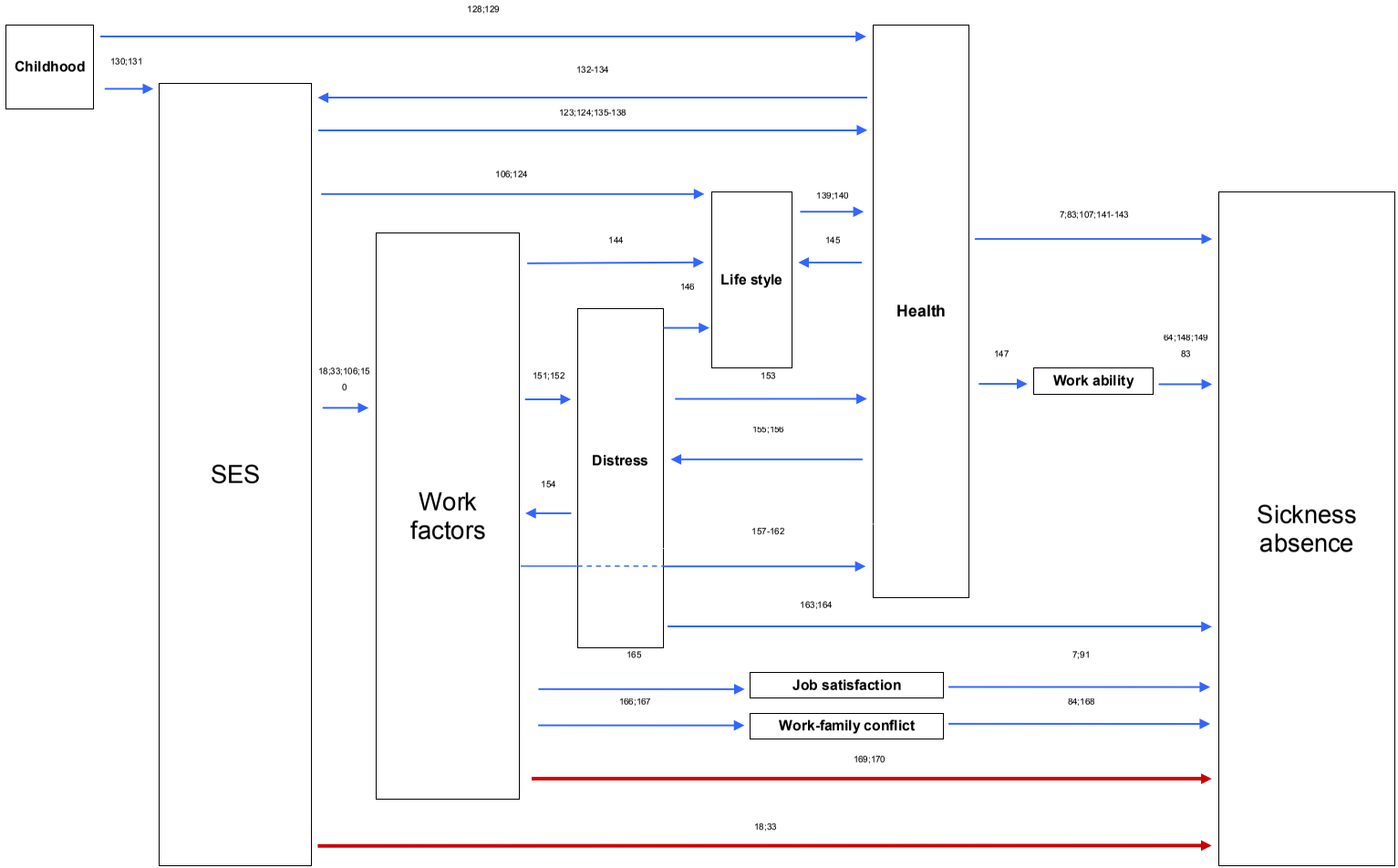


Figure 2
Hospital study. The distribution of short, medium and long absence spells.

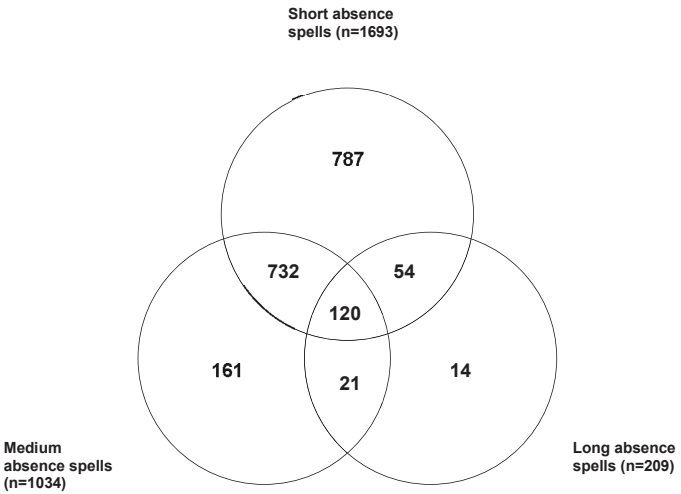
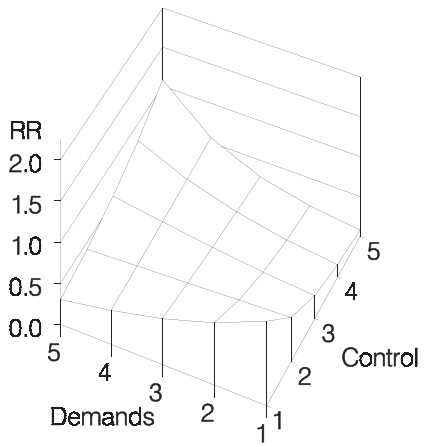


Figure 3
Hospital study. Rate ratios (RR) of medium sickness absence spells by combinations of demands and control. The RRs are relative to a RR=1 for the lowest level of demands (score=1) and the highest level of control (score=1). For the highest level of demands (score=5) and the lowest level of control (score=5) the RR was 1.08. All other RR's were below unity.



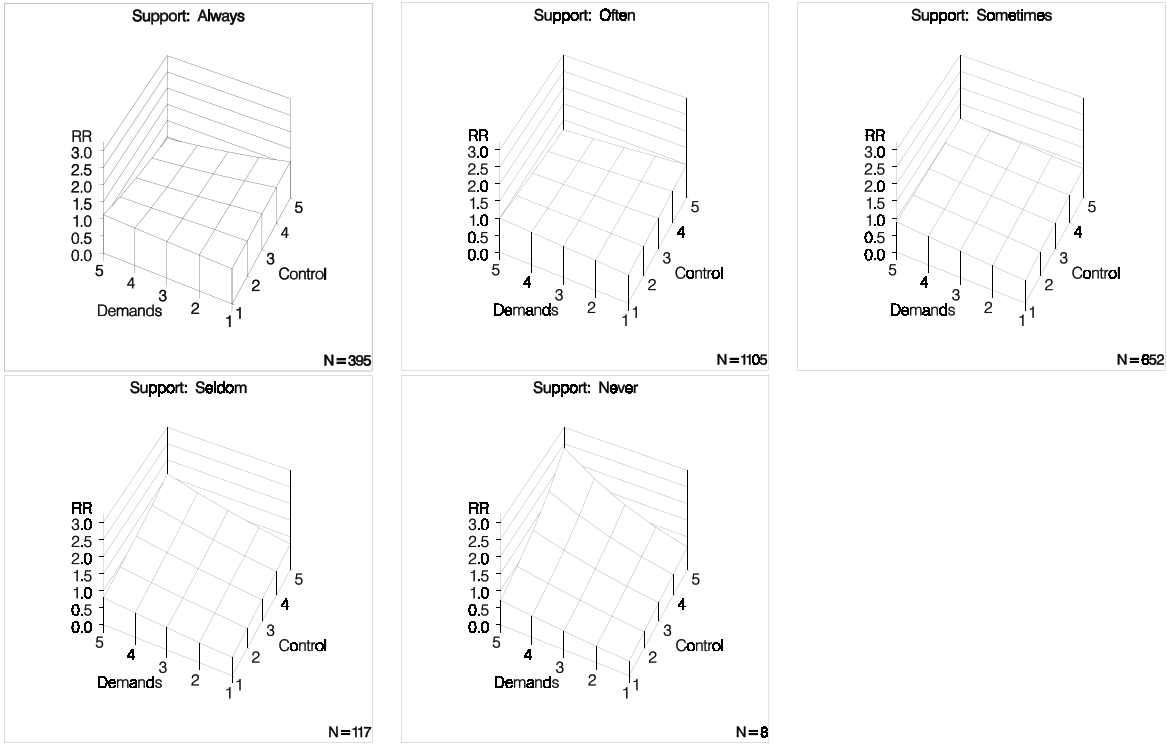


Figure 4. Hospital study. The demand-control-support interaction. Rate ratios (RR) of short sickness absence spells by combinations of demands, control and support. The RRs are relative to a RR=1 for the lowest level of demands (score=1), the highest level of control (score=1) and the highest level of support (always available). (Front corner of upper left panel). When support is always or often available, the combination of high demands (score=5) and low control (score =5) reduces the risk of short sickness absence (Back corner in the two first panels.)
When support is only sometimes, seldom or never available, the same combination increases the risk. When support is only sometimes, seldom or never available, the three situations (corresponding to 3 corners) where 1) demands are low and control is high,2) both demands and control are high and 3) both demands and control are low, decreases the risk of short sickness absence compared to RR=1.

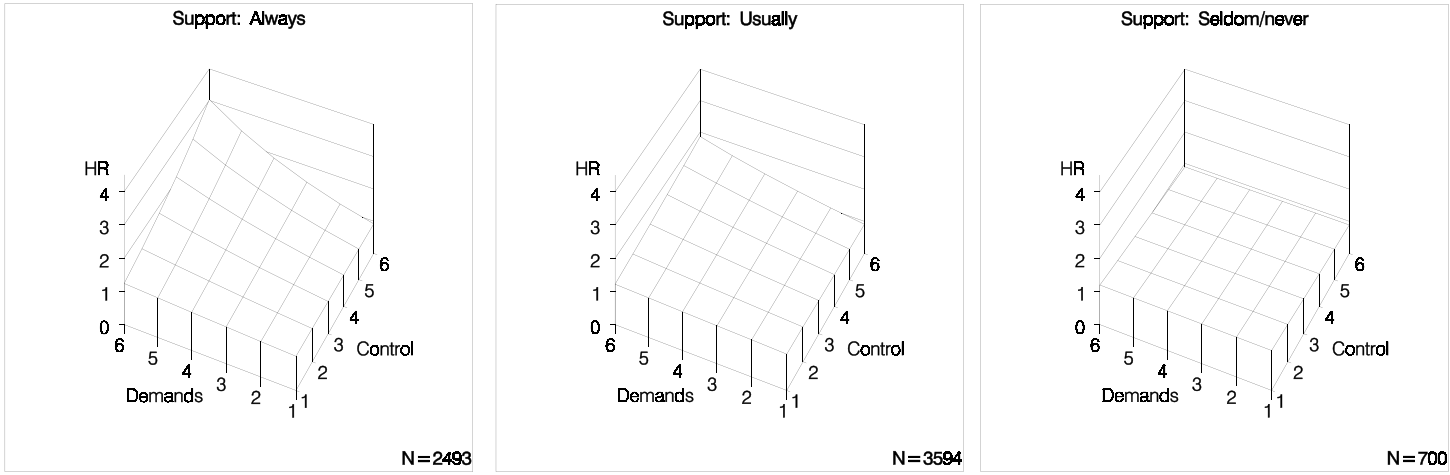


Figure 5

ASUSI study. The demand-control-support interaction. Hazard ratios (HR) of any sickness absence (>14 days) by combinations of demands, control and support. Three panels for support “almost always”, “often” and “sometimes” are omitted, since their response surface is in between their neighbouring panels. The HRs are relative to a HR=1 for the lowest level of demands (score=1), the highest level of control (score=1) and the highest level of support (always). (Front corner in the left panel.) When support is always available, the HR increases markedly for the combination of high demands (score=6) and low control (score=6). (Back corner in the upper left panel) When support becomes poorer (middle and right panel) this pattern gradually disappears and the response surface becomes almost flat for the lowest level of support (right panel). For the lowest level of support, the HR for the combination of high demands (score=6) and low control (score=6) is slightly below unity (Back corner in right panel.)

Table 1. Studies analysing socioeconomic status (SES) and sickness absence (SA).

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
Alexopoulos et al, 2008[171]	Greece All employees of a shipyard company 853 participants 98.5%	Education, dichotomised.	SA data from Social Insurance Institute. Time to first spell of SA due to low back pain. Time to RTW. Cox proportional hazard model. 1 year follow-up.	Age. Low back pain, other musculoskeletal complaints, health care use and SA during previous 12 months, due to low back pain or not. Perceived general health, need for recovery. Night shift; family situation; physical and psychological risk factors at work; etc.	Yes	Not investigated
Benavides et al, 2003[172]	Spain All workers in a bus company 2.893 participants	Occupational groups, 8 groups.	Rates of work related SA spells > 3 days Andersen-Gill approach to the proportional hazard model. SA data from company records.	Age, gender, civil status, barndom, ansættelsesvarighed, rygning, kroniske sygdomme. Ikke kontrol-leret for arbejdsforhold, idet SESmålet antages som proxy for arbejdsforhold	Yes	Not investigated
Brage et al, 1998[173]	Norway The economically active population in Norway. except civil servants 1.978.030 persons 141.839 cases	Income, 4 groups.	SA data from the National Sickness Benefit Register. SA spells > 14 days due to musculoskeletal health problems. Cumulative incidence ratios (Poisson regression), episode frequency – two or more episodes compared to one episode (logistics regression) episode duration (Cox regression)	Age, gender, marital status diagnoses	Yes	Not investigated
Breslin et al, 2008[29]	Canada (SLID - Survey of Labour and Income Dynamics) A panel of all persons living in Canada, except few groups. 31.000 persons Response rate not stated.	Education, 3 groups. Occupation, 3 groups.	Self-reported SA data. The first occurrence of SA ≥ 1 week due to work-related illness or disability in each new job in the previous calendar year. Hazard models of time to SA	Gender, age, hours worked per week, having more than one job, tenure, union membership etc.	Yes	Not investigated

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
Campostrini et al, 2000[174]	Italy (The Italian Labour Force Survey 1990) 383.685 persons in the general population Selection criterion and response rate not stated.	Occupation, 4 groups.	Self-reported data on the actual working status.	Separate analyses for men and women. Standardizes by age. Not further adjusted.	Yes	Not investigated
Christensen et al, 2008[31]	Denmark (DWECS - Danish Work Environment Cohort Study) Random sample of Danish employees. 5.221 participants 75%	Occupation, 5 groups.	SA data from national register of social transfer payments. 18 months follow-up. Rate of SA spells ≥ 8 weeks. Poisson regressions models.	Separate analyses for men and women. Age, family status, lifestyle factors (health behaviour), physical and psychosocial work conditions.	Yes	Physical work environment. Health behaviour. Psychosocial work environment (only in women).
Cvetkovski et al, 2006[175]					Yes	
d'Almeida et al, 2008[30]	France Workers from the national power and gas company. 134,255 participants.	Occupation, 4 groups.	Objective SA data. Retrospective, 1 year. One spell due to upper limb disorder. Yes/no.	None	Yes	Not investigated
Fuhrer et al, 2002[22]	France England (GAZEL) Employees of the national gas and electricity com-pany. 6818 participants 45 % (Whitehall II) Civil servants in London. 5825 participants. 73%	Occupation, 3 groups.	Objective SA data. Prospective, up till 4 years Spells of > 7 days. Poisson regression	Age, fathers social class, heigth, education, smoking, alchhol, fruit/vegetables intake, BMI, marital status, decision latitude, demands. (women in Gazel only age, fathers social class, height, BMI, decision latitude, demands.) Separate analyses for men and women.	Yes	*Fathers social class, heigth, education, smoking, alchhol, fruit/vegetables intake, BMI, marital status, decision latitude, demands* analysed to-gether explained some of the differences. Because of the different distributions of life style factors in the 2 countries, it is concluded that it is unlikely that these contribute to the explanation.

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
Hansen et al, 2008[32]	Norway (Norwegian Level of Living Survey) Representative sample of employees in Norway. 6485 participants	Occupation, 6 groups.	Self-reported SA data. Retrospective, 1 year. One spell of ≥ 14 days, yes/no. Logistic regression.	Age, children, marital status, health complaints, full time work, seniority, permanent employment, job insecurity, physical work environment, ergonomic work environment, demand, control, organizational climate. Separate analyses for men and women.	Yes (not when fully adjusted)	*Age, children, marital status, health complaints* analysed together. *Physical and ergonomic work environment* analysed together.
Isacsson et al, 1992[176]	Sweden All persons registered with the National Health insurance scheme in Malmö. 124,411 participants	Income, 11 groups.	Objective SA data. Mean number of days per person per year.	Age	Yes, above an income of 100,000 SEK. No, for an income below 100,000 SEK	Not investigated
Johansson et al, 2009[34]	Sweden Random sample of inhabitants in Stockholm. 8539 participants 56 %	Occupation, 3 groups	Self-reported SA data. Retrospective, 1 year. Total number of SA days, categorized as 0 days, 1-30 days and >30 days. Polytomous logistic regression.	Age, work factors (adjustment latitude, stimulating work, attendance requirement), self-rated health. Separate analyses for men and women.	Yes for > 30 days. No for 1-30 days.	*Work factors and self rated health* for SA of > 30 days
Krantz et al, 2002[35]	Sweden Random sample of women in a rural community. 397 participants 82%	Education, dichotomised. Occupation, dichotomised. Income, dichotomised.	Objective SA data. Prospective, 1 year. Spells of > 14 days. Odds ratios.	-	No	Not investigated
Lim et al, 2002[23]	Thailand All personnel in a hospital. 2181 participants.	(Education, 3 groups.) Occupational groups, hospital, 6 groups. (Occupational grade, 3 groups.)	Objective SA data. Retrospective, 3 years Number of spells of 1-2 and of ≥ 3 days Negative binominal regression.	Gender, age, marital status, education, grade, civil servant status, shift work.	Yes for occupational groups and grade. No for education.	*Gender, age and marital status* analysed together explained some of the differences for spells of ≥ 3 days *Grade, civil servant status, shift work* analysed together explained some of the differences for both spells of 1-2 days and of ≥ 3 days.

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
Lindberg et al, 2006[56]	Sweden Random sample of full-time working men and full- and part-time working women in Sweden, aged 35, 45 and 55 years. 6337 participants 65%	Education, dichotomised. Income, dichotomised.	Objective SA data. Prospective, 1 year. Retained work ability = not having SA spells > 14 days in follow-up Logistic regression	Age, marital status, physical work factors, psychosocial work factors (i.e. job strain, relaxed, active and passive) employment sector, previous SA	Yes for men education, not for women. No for income	Not investigated
Lund et al, 2007[28]	Denmark (DWECS – Danish Work Environment Cohort Study) Random sample of Danish employees. 5357 participants. 75 %	Education, 5 groups.	Objective SA data. Spell of ≥ 8 weeks. Logistic regression.	None	Yes	Not investigated
Marmot et al, 1995[7]	England (Whitehall II) Civil servants in London. 10.308 participants. 73%	Occupation, 6 groups.	Objective SA data. Prospective. Number of spells of 1-2, 3-7, 8-21, >21 days. Rates per 100 person years by direct standardisation.	Age	Yes	Not investigated
Melchior et al, 2005[26]	France (GAZEL) Employees of the national gas and electricity com-pany. 11,733 participants 45 %	Occupation, 6 groups.	Objective SA data. Prospective, 6 years. SA du to all causes and due to the 4 most common medical causes. Poisson regression i sekundære analyser opdelt i <8, 8-21 dage, >21 dage	Age, marital status, smoking, alcohol, BMI, stressful life events, physical work (postural constraints, occupational hazards, night work, outdoor work), customer contact, job stress (control, demands, support). Separate analyses for men and women.	Yes	*Work environment* explain together 16 % for men and 25 % for women in all-cause SA
Moncada et al, 2002[24]	Spain (Casa Gran) All civil servants in Barcelona employed at least 6 month. 20,648 participants	Occupation, 6 groups.	Objective SA data. Retrospective, 10 years. Spells of 1-10 and > 10 days. Negative binominal regression.	Separate analyses for men and women.	Yes	Not investigated

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
Morikawa et al, 2004[25]	Japan England Male employees in a sash and zipper factory in Japan. 2504 participants 89% (Whitehall II) Male civil servants in London. 6290 participants. 73%	Occupation, Higher white-collar compared to lower white-collar Higher blue-collar compared to lower blue-collar (Japan). Higher white-collar compared to lower white-collar (England)	Objective SA data. Prospective, 8 years. First spell of > 7 days. Cox proportional hazard regression.	Age, smoking, drinking, physical activity, self-rated health.	Yes	*Smoking, drinking, physical activity, self-rated health* analysed together some of the differences in white-collar in Japan and England
Morken et al, 2003[143]	Norway Workers in 8 aluminium plants. 5654 participants. 92%	Occupation, dichotomised.	Self-reported SA data. Retrospective, 1 year. Total number of days due to musculoskeletal disorders, 1-12 days and 12 days in total analysed separately. Cox regression.	Age, gender, BMI, smoking, physical activity, shift work, job strain, social support, musculoskeletal symptoms from neck, shoulders, elbows, hands, upper back, lower back, hips, knee and feet.	Yes	Not investigated
Niedhammer et al, 2008[177]	France (SUMER) National French working population 24.486 participants	Occupation, 4 groups.	Self-reported. > 8 days within the previous 12 months Logistic regression analysis, separately for men and women.	Age, work status, working hours, time schedules, Physical, biological and chemical exposure, psychological demands, decision latidude, social support, bullying, violence	Yes	Not investigated
Niedhammer et al, 2008 [33]	France (SUMER) National French working population 24.486 participants 97%	Occupation, 4 groups	Self-reported SA data. Retrospective, 1 year. Total number of SA days ≥ 8 days: yes/no Logistic regression analysis.	Age. Work contract, part time work, work schedules. Psychosocial work factors (demands, control, decision authority, skill discretion, support from collegues, support from supervisors, bullying, violence from public), physical exposure (noise, thermic constraints), ergonomic exposures (manual handling, postural and articular constraints, vibrations, driving), biological exposure, chemical exposure.	Yes	*Work schedules, physical expo-sure, psycho-social work factors.* Detailed analyses: *Decision authority, skill discretion.*

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
North et al, 1993[18]	England (Whitehall II) Civil servants in London. 9.072 participants. 73%	Occupation, 6 groups.	Objective data. Employers record. Number of spells of 1-7 and > 7 days. Poisson regression.	Age, smoking, alcohol, control at work, variety and use of skills, support at work, work pace, job satisfaction, negative support outside work, difficulty paying bills, ethnic group. Separate analyses for men and women.	Yes	*Smoking, alcohol, psychosocial work conditions (control, variety and use of skills, support, pace, job satisfaction), negative support outside work, difficulty paying bills and ethnic group* accounted together for about 1/3 of the differences.
Piha et al, 2007[27]	Finland (Helsinki Health Study) Municipal employees in Helsinki aged 25-59 years. 24.029-27,861 participants.	Education, 3 groups. Occupation, 5 groups. Income, 5 groups.	Objective data. Personnel register. Spells > 3 days. Linear regression.	Age. Separate analyses for men and women.	Yes	Not investigated
Pines et al, 1985[36]	Israel All employees in a hospital. 3020 participants. 100%	Occupational groups, 7 groups.	Objective data. Employer records. Mean of total number of days and spells.	Gender and age or marital status or duration of employment	Yes	*Gender*
Sell et al, 2009[149]		Education, no. of years Income efter skat, i groups pr. 1000 kr./måned	Objective data. spells of ≥ 14 days	arbejdsevne, gender, age, children, civil status, livsstilsfaktorer	Yes	Not investigated
Stansfeld et al, 1999[20]	England (Whitehall II) Civil servants in London. 9.564 participants. 73%	Occupation, 6 groups.	Objective data. Employers record. SA in a job secure and in a job insecure period. Number of spells of 1-7 and > 7 days. Poisson regression.	Age Separate analyses for men and women.	Yes	Not investigated

Reference	Country (Study) Sample Response rate	SES measure	Outcome –sickness absence	Adjustment	low SES predict SF	Covariates explaining SES differences
Taimela et al, 2007[178]	Finland Employees in one corporation in construction industry and service and maintenance of buildings. 1341 participants 48%	Occupation, white collar men, blue collar men and white collar women	Objective data Retrospective, 1 year. SA data from employer's records. Any absence. Number of days in total. Zero inflated binominal regression. Negative binominal regression	Age, self-reported health complaints, BMI, alcohol, depression-score, stress and fatigue, sleep, alertness, pain, impairment due to musculoskeletal problems at work, future work-ability	Yes	Not investigated
Vahtera et al, 1999[21]	Finland All municipal workers in 3 towns. 2793 participants	Occupation, 3 groups. Income, 8 groups for men, 12 groups for women.	Objective data. Only register data. Sick-leave certificates from employers. Number of spells of 1-3 days and > 3 days. Poisson regression.	Age. Length of service. Town of workplace. Separate analyses for men and women.	Yes	Not investigated

Table 2.
Prospective studies* analysing strain or iso-strain and objectively registered sickness absence (SA). 1979 – 2009.

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Moreau et al, 2003[47]	Belgium (Belstress) Employees aged 35-59 years in 24 large companies or public administration. 20,463 participants. 48 % Same cohort as in 2004	Strain not examined. Iso-strain: high demands + low control + low support. (Compared to all other combinations of demand, control and support) Demands, control and support dichotomised around gender specific medians	1 year follow-up At least one spell of ≤ 7 days At least one spell of > 7 days At least 3 spells / year High incidence of SA: total number of SA days above the quartile of the distribution of SA days (= 10 days for men, 15 days for women) Logistic regression Analyses differ from the 2004 article by including spells of 1 day and by the definition of long spells as spells > 7 days.	Age, mother tongue, country of birth, education, occupation, marital status, social support outside work, children, responsibility towards ill or elderly persons, sector of activity, physical demands at work, job insecurity, job satisfaction, type of coping, locus of control, smoking, alcohol, physical activity, blood pressure, cholesterolaemia, BMI, diabetes, ischaemic ECG or angina, self perceived health, anxiety, depression. Separate analyses for men and women.	A significant association between iso-strain and SA spells of > 7 days for men and women. A significant association between iso-strain and high incidence of SA for men. No significant association between iso-strain and high incidence of SA for women. No significant association between iso-strain and SA spells ≤ 7 days or ≥ 3 spells/ year.
Verhaeghe et al, 2003[60]	Belgium (Belstress) Employees aged 35-59 years: 315 health care workers from 2 hospitals and 612 matched controls. 31-78 %	Strain: high demands + low control. (reference group not mentioned) Demands and control dichotomised around the median. Iso-strain not examined.	1 year follow-up Any SA. Number of SA days above the highest quartile of the distribution of SA days (= 11 days for health care workers, 10 days for controls) yes/no. Logistic regression	Gender, age, education.	A significant association between strain and any SA for health care workers. No significant association for SA days above the quartile of the distribution. No significant association for controls.

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Moreau et al, 2004[59]	Belgium (Belstress) Employees aged 35-59 years in 24 large companies or public administration. 20,463 participants. 48 % Same cohort as in 2003	Strain: high demands + low control (Compared to low demand + high control) Iso-strain: high demands + low control + low support (Compared to all other combinations than iso-strain and than low demand + low control + low support) Demands, control and support dichotomised around gender specific medians	1 year follow-up of SD spells of > 1 day: At least one spell of ≤ 7 days At least one spell of ≥ 28 days At least 3 spells / year High incidence of SA: total number of SA days above the highest quartile of the distribution of SA days (= 9 days for men, 10 days for women) (Other definitions were tested and gave in general similar results: at least 1 spell of ≤ 3 days, at least 1 spell of ≥ 10 days and total no. of days ≥ C60 of the distribution (4 days in men, 7 days in women)) Logistic regression Poisson regression for spells ≥ 28 days	Age, occupation, education, marital status, country of birth, language, social support outside work, smoking, alcohol, blood pressure, cholesterolaemia, BMI, diabetes, ischaemic ECG or angina, respiratory problems, self perceived health, depression. Separate analyses for men and women. SES: ISCO-88 (ISCO 1–2/ 3–5/ 7–9) og uddannelse	Strain: For men a significant association was found for spells ≤ 7 days, spells ≥ 28 days and for high incidence of SA. No significant associations for women. Iso-strain: For men significant associations were found for all outcomes. For women a significant association was found for repeated spells.
Clumeck et al, 2009[61]	Belgium (Part of Belstress I, which is part of JACE) Employees aged 35-59 years in 11 large industries/ administrations. 9396 participants (8550 participants?) 48 %	Strain: high demands + low control (Compared to low demands + high control) Iso-strain: high demands + low control + low support (Compared to all other combinations of demands and control + high support) Demands, control and support dichotomised around the median.	3 years of mean follow-up ≥ 1 spell of >28 days due to depression Logistic regression	Age (above/below median (45 years)), occupational group, living situation (alone/not alone), baseline depression. Separate analyses for men and women.	A significant association between strain and SA for men. No significant association for women. A significant association between iso-strain and SA for men. No significant association for women.
Bourbonnais et al, 2001[58]	Canada Female nurses at 6 hospitals in Quebec. 1793 participants. 62 % (58 % responded *and* agreed to examination of sick leave records, calculated)	Strain: high demands + low control (Compared to low demands + high control) Demands, control and support dichotomised around the median. Iso-strain: It is not specified how iso-strain is analysed.	12-20 months follow-up. (The study is not only prospective for all participants, but retrospective and prospective for some participants) Number of spells of 1-3 or 1-5 days Number of spells of > 3 or > 5 days Poisson regression	Probably adjusted for age, hospital, type of unit, tenure, full-time/part-time, schedule, working hours per week, working days per 2 weeks, smoking, alcohol, non-work social support, stressful life events, type A behaviour, domestic workload, job security.	A significant association between strain and SA spells of 1-3 or 1-5 days No significant association with longer spells. Support did not modify the association between job strain and SA.

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Bourbonnais et al, 2005[49]	Canada Nurses in 13 health care facilities in Quebec 1314 participants 66 % (x 77 %)	Strain: high demands + low control (Compared to low demands + high control) Demands and control dichotomised around the median from another population of nurses. Iso-strain: If significant in stratification, an interaction term with support was introduced in the model.	17 months of follow-up Number of SA spells > 3 days due to mental health problems, or due to all causes Survival analysis (Andersen-Gill method for the Cox model)	Age, occupational status, previous absence	A significant association between strain and SA No modifying effect of support. (When stratified in low and high rewards, a significant association was only found for strain combined with low rewards.)
Parkes et al, 1991[48]	England Male civil driving examiners 560 participants 83 %	Demand x control as interaction term in regression analyses also including demand and control. Iso-strain not examined.	2 years of follow-up Number of absence spells ≤ 1 week Multiple regression	Age, negative affectivity, smoking, locus of control	No significant association.
North et al, 1996[62]	England (Whitehall II) Civil servants in London. 9072 participants. 73%	Strain: high demands + low control (Compared to all other combinations) Iso-strain: high demands + low control + low support. (reference group not mentioned) Demands, control and support dichotomised around the median. Demand and control measured both by self-report and by personnel managers rating.	20 month follow-up. Number of spells of ≤ 7 days Number of spells of > 7 days Poisson regression	Age, grade. Separate analyses for men and women.	A significant association between strain and SA spells of ≤ 7 days for men. No significant associations for women. No significant association with SA spells > 7 days. No modifying effect of support (same results when stratified by support)

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Head et al, 2006[63]	England (Whitehall II) Civil servants in London. 3817 participants. 83 % (x 73%)	Change in strain – between the strain groups: High: high demands + low control Low: low demands + high control Medium: other combinations Demands and control dichotomised around the median. Demand and control measured both by self-report and by personnel managers rating. Iso-strain not examined.	5,3 years average follow-up Number of spells of ≤ 7 days Number of spells of > 7 days Poisson regression	Probably gender, age and grade, and possibly more covariates, but this is not clearly indicated for the strain analyses.	A significant association between increase in job strain and SA spells > 7 days, but the result may reflect the combined additive effect of adverse changes in demands and control. No significant association with shorter SA spells.
Vahtera et al, 1996[179]	Finland Local government employees of the town of Rasio. 856 participants. 95 %	Demand x control and demand x control x support as interaction terms in regression analyses also including demand and control, and in the iso-strain analyses including support. Separate analyses were made for supervisor support and for co-worker support. Demands was measured both by self-report and as the mean of self-reports in the same occupations and place of work.	3 years follow-up. Number of spells of 1-3 days Number of spells of > 3 days Poisson regression	Age. Separate analyses for men and women.	No significant association between strain and SA No significant associations with iso-strain.
Vahtera et al, 2000[68]	Finland Municipal employees with no medically certified SA during one year prior to baseline. 530 participants. 79 %	Change in demands, control and support. Interaction terms analysed between one baseline job characteristic and change in another job characteristic. Iso-strain not examined.	6.7 years of mean follow-up Number of SA spells > 3 days Poisson regression	Gender, age, SES, smoking, alcohol, sedentary lifestyle, BMI	No significant interaction between demands and change in control or between control and change in demands

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Ala-Mursula et al, 2005[57]	Finland (10 town study) Public sector employees without SA spells > 3 days in the year preceding the survey. 16,139 participants 67 %	Strain: high demands + low control (Compared to low demand + high control) Demands and control dichotomised around the median. Iso-strain not examined.	28 months of mean follow-up Number of SA spells > 3 days Poisson regression	Age, education, occupational group, schedule, marital status, children, smoking, alcohol, sedentary life style, overweight. Also analysed in combination with good/poor control over daily working hours and good/poor control over days off. Separate analyses for men and women.	A significant association between strain and SA. When analysed in combination with control over daily working hours and control over days off, significant associations were found in most analyses.
Kujala et al, 2006[64]	Finland (NFBC-66) Employed people from the Northern Finland Birth Cohort 1966. 3725 participants 76 %	Strain: high demands + low control (Compared to high demands + high control) Demands and control dichotomised around the median. Iso-strain not examined.	1 year follow-up At least 1 SA spell of > 9 days Logistic regression	Work ability, occupation (ISCO-88), support, marital status, number of children, physical activity, BMI, smoking, alcohol. Separate analyses for men and women. All participants had the same age.	A significant association between strain and SA for men. No significant association for women.
Suominen et al, 2007[65]	Finland (Perceived Health and Life Control Study) People in gainful employment from a random sample of the Finnish population. 1806 participants 68 %	Strain: high demands + low control (Compared to low demands + high control) Demands and control dichotomised around the median. Iso-strain not examined.	8.9 years of mean follow-up (2 years were retrospective, the remaining years were prospective) Number of SA spells > 8 days Binomial regression	Age, SES, alcohol, physical exercise, life events. Separate analyses for men and women.	A significant association between strain and SA for men. No significant association for women.

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Niedhammer et al, 1998[50]	France (GAZEL) Middle-aged employees of the national electricity and gas company. 12,555 participants. 74 % (x 45%)	Strain: two-way interaction Iso-strain: three-way interaction Demands, control and support dichotomised around the median.	1 year follow-up Number of SA spells Number of SA days Poisson regression Separate analyses were made for spells of 1-7 days and for spells of > 7 days. It is not clear whether these analyses only were made for demands, control and support separately, or if they also were made for the interactions. It is mentioned that the results were the same for short and long spells.	Age, smoking, alcohol, marital status, number of children, educational level and occupation. Separate analyses for men and women.	No significant interactions were found.
Melchior et al, 2003[35]	France (GAZEL) Middle-aged employees of the national electricity and gas company. 12,555 participants. 72 % (x 45 %)	Strain: two-way interaction Demands and control dichotomised around the median, and around the quartiles. Iso-strain not examined.	Up to 6 years follow-up Number of spells Poisson regression	Not clear which covariates were included in the analyses of strain and iso-strain. Separate analyses for men and women.	No significant interactions
Krantz et al, 2002[35]	Sweden Random sample of women in a rural community. 301 participants. 82 %	Strain: high demands + low control (reference group not mentioned) Demands and control dichotomised around the median. Iso-strain not examined.	1 year follow-up. ≥ 1 SA spell of 15-180 days OR (95% CI)	No adjustment	No significant association in unadjusted analyses.
Bildt et al, 2006[67]	Sweden Inhabitant aged 45-64 years born and living in the town of Gnosjö 473 participants 47 % (x 44 %)	Strain is only defined in the discussion as a combination of high demands and low control. Iso-strain not examined.	3 years of follow-up Absence/no absence Logistic regression	It is not clear whether the results are from univariate or multivariate analyses. Separate analyses for men and women.	Strain was a significant causal factor for SA in women.

Reference	Country (Study) Sample Response rate**	Strain / iso-strain measure	Sickness absence	Adjustment	Results from adjusted analyses concerning strain and iso-strain
Lindberg et al, 2006[56]	Sweden Random sample of full-time working men and full- and part-time working women in Sweden, aged 35, 45 and 55 years. 6337 participants 65%	Strain: high demands + low control. (Compared separately to other combinations of high/low demands and high/low control) High demands defined as ≥ 16 (possible scale values 5-20). Low control defined as ≤ 18 (possible scale values 6-24). Iso-strain not examined.	1 year follow-up Retained work ability = not having SA spells > 14 days in follow-up Logistic regression	Age, education, income, personal finances, marital status, physical work factors, other psychosocial work factors employment sector, previous SA. Separate analyses for men and women.	No significant association in adjusted analyses.
Smulders et al 1999[51]	The Netherlands All male employees in a public technical maintenance firm. 1755 participants. 70%	Demand x control as interaction term in regression analyses also including demand and control. Iso-strain not examined.	1, 2 and 3 years of follow-up. Number of days Number of spells Poisson and linear regression.	Age, education, prior absence	No significant association with any outcome.
de Jonge et al, 2000[52]	The Netherlands (SMASH) Employees from 34 industry and service companies. 1412 participants. 87 %	Strain and iso-strain analysed as multiplicative interaction terms including the main effects in regression analyses. Control analysed separately as skill discretion and decision authority.	Number of days Number of spells Hierarchical regression	Gender, age, education	No significant effects on any outcome of any of the interactions.
Elders et al, 2003[54]	The Netherlands Workers in a scaffolding company. Probably only men. 288 participants. 86 %	Strain: high demands + low control. Demands and control were divided into quartiles, and values above the highest quartile were combined. Iso-strain not examined.	3 years follow-up of SA due to low back pain: At least 1 SA spell of ≤ 14 calendar days/ 3 years. At least 1 SA spell of > 14 calendar days/ 3 years. Among workers with SA: Number of SA spells Number of calendar days of SA Percentage of working days of SA Generalized log linear regression. Time to first SA. Survival analysis.	Age	No significant association with any outcome in univariate analyses.

* Two of the studies are not exclusively prospective, because they to a lesser extent also include retrospectively registered sickness absence.
** In some studies, response rates of the initial cohort study is mentioned in brackets in addition to the response rate of the actual study

Table 3. Studies analysing effort reward imbalance (ERI) and sickness absence (SA).

Reference	Country (Study) Sample Response rate	ERI measure	Adjustment	Sickness absence measure	Results concerning ERI
Ala-Mursula et al, 2005[57]	Finland. (10 town study) Public sector employees without any SA spell > 3 days in the preceding year. 16,139 participants 67 %	ERI = effort / reward, divided into quartiles	Age, education, occupation, work contract, marital status, children, smoking, alcohol, sedentary lifestyle, overweight. Separate analyses for men and women. Separate analyses for good and poor control over daily working hours, and for good and poor control over days off.	Objective SA data Prospective, mean follow-up time 28,2 months Number of SA spells > 3 days Poisson regression	Highest quartile of ERI was associated with SA, both in case of good and poor control over working hours and in case of good and poor control over days off. ERI predicted more strongly SA in case of poor work time control, except for men with poor control over days off.
Bourbonnais et al, 2005[49]	Canada Nurses in 13 health facilities. 1454 participants 77 %	ERI = effort/reward > 1 Type A surrogate for overcommitment.	Age, family status, seniority, job status, work shift, smoking, alcohol, off-work social support, previous absence.	Objective SA data. Prospective, about ½ year of follow-up for ERI data Number of SA spells > 3 days due to mental health problems, or due to all causes Survival analysis	ERI associated with increased incidence of SA for all causes and for mental health problems.
Eriksen et al, 2003[77]	Norway Random sample of all unionised nurses' aides. 4.931 participants 62 %	ERI = demands x rewards as interaction term.	Age and gender.	Self-reported SA data Prospective, 3 months. At least one SA spell of > 3 days. Logistic regression	No interaction between demands and reward in preliminary analyses.
Fahlen et al, 2009[71]	Sweden (SKA, sick-leave, culture and attitudes) All employees at the Swedish Social Insurance Agency 3485 participants 65 %	ERI = Effort/ reward > highest quartile. Compared to lower ERI.	Probably age	Self-reported SA data. Retrospective, interval of time not indicated. Cases: At least one SA spell of > 3 weeks Logistic regression only including women	ERI associated with at least one previous SA spell of > 3 weeks in women
Godin et al, 2004[72]	Belgium (Somstress) Employees in a hospital, two insurance companies and a telecommunication company. 3804 participants 40 %	ERI = effort/reward > upper quartile Overcommitment: > upper tertile	Age, gender, education, instability of workplace, demand, control, support.	Self-reported SA data Retrospective, 1 year 1) ≥ 3 SA spells 2) > 1 week 3) ≥ 1 SA spell ≥ 2 weeks Logistic regression ERI and demand-control analysed in the same model	ERI associated with at least 1 week of SA, and at least 1 SA spell of ≥ 2 weeks

Reference	Country (Study) Sample Response rate	ERI measure	Adjustment	Sickness absence measure	Results concerning ERI
Hanebuth et al, 2006[73]	Germany Employees from an airplane-manufacturing company.	ERI = effort / reward Overcommitment	Age, gender, smoking, liver enzymes, physical activity, BMI, income, occupation	Objective SA data Retrospective, 1 year Number of SA spells of 1 day, 2-3 days, 4-5 days and 5-29 days. Total number of days Poisson regression	ERI associated with spells of 2-3 days and 4-5 days. No association with overcommitment.
Head et al, 2007[74]	England (Whitehall II) Civil servants in London 9179 participants 73 %	ERI = effort / reward, divided into three equally sized groups based on the distribution of the ratio.	Age, employment grade, physical illness and long standing illness at baseline, relational justice. Separate analyses for men and women.	Objective SA data. Prospective. 2 follow-up periods each of 5 years. Number of SA spells of 1-7 days and of > 7 days. Poisson regression	ERI associated with 1) number of SA spells 1-7 days: For men in the first follow-up period. For women in the second follow-up period 2) number of SA spells > 7 days: For men in both follow-up periods.
Peter et al, 1997[78]	Germany Male middle managers in a car-producing company. 146 participants 95 %	Because of small-scale data, ERI is defined as being present if at least one indicator of high effort and at least one indicator of low reward are significantly associated with the outcome.	No adjustment (in chi-squared tests)	Objective SA data. Retro-/prospective, 1 year Spells of 1-3 days. Spells > 3 days. ≥ 2 spells of any length. (All compared to no absence) Chi-squared test (to define significance of associations from bivariate analyses) Logistic regression (Analyses were repeated without persons having both short and long spells.)	No indicator of high efforts was overrepresented in the groups of participants with the different SA outcomes, and therefore no association was demonstrated with the ERI measure.
Sanderson et al, 2008[79]	Australia Employees at call-centres 204 participants 53 %	ERI = effort/reward > median	Age, gender, education, marital status, sickness absence at baseline	Self-reported SA data. Prospective, any SA during the past 4 weeks, measured 5 months after baseline log binomial regression	No significant association.
Taris, TW et al, 2002[76]	Finland Representative sample of Finnish workers 1297 participants 66 %	"ERI" = "effort"/"reward" > 1.0 (compared to "ERI" < 1.0 and to "ERI" = 1.0) "Intrapersonal equity measure" corresponds to ERI. "Effort" measured as "investment". "Reward" measured as "outcomes". Intrapersonal equity measure = "investment" / "outcomes".	Age, gender, education, number of years of employment	Self reported SA data. Retrospective, 1 year. Any absence due to overstrain or fatigue Analysis of variance	A non-linear effect of equity was found for SA. ("ERI" = 1.0 had the lowest score of SA compared to "ERI" < 1.0 and "ERI" > 1.0)

Reference	Country (Study) Sample Response rate	ERI measure	Adjustment	Sickness absence measure	Results concerning ERI
Van Vegchel et al, 2005[75]	Netherlands Employees in nursing homes Study 1: 405 participants 73 % Study 2: 471 participants 77 %	ERI = effort / reward ERI = effort x reward ERI = effort – reward + constant	Age, gender, education, fulltime/part-time	Objective SA data Retrospective, 1 year Total number of days Number of spells Hierarchical multiple regression Incremental F-test to test if interaction term explained variance over and above variance explained by the independent variables.	Number of days: effort x reward effort – reward + constant Number of spells: effort x reward Same results in both studies.

Table 4 Participants in Study 1 and 2

Distributed questionnaires	3199
Returned questionnaires	2687
Employment stopped before Jan 1st 2001	- 148
Changed to other work unit before by Jan 1st 2001	- 123
Invalid employment data	- 13
Invalid sickness absence data	- 14
Did not fit in the occupational groups of the study	- 58
Participants	**2331**

Table 5 Participants in Study 3

Random sample of inhabitants aged 19-64 years	30.000
In employment for at least 80% of the time during the previous year or for 6 out of the previous 12 weeks *and* without more than 10 weeks of sickness absence in the previous year *and* of Danish origin = Distributed questionnaires	21.313
After excluding students, people on parental leave, those sick listed at the time of answering the questionnaire, deceased, and persons without a valid address = Study population	20.481
Returned completed questionnaires among study population:	
Participants	**14.241**

Table 6. ASUSI study. Covariates included as potential confounders. Probability of trend for sickness absence in bivariate analyses, and of no effect (HR=1) in the final multiple regression model. Source of covariates are shown in footnotes.

Group of covariate	Covariate	Measure	Cross-tabulation Test for trend	Test for no effect (HR=1) final model
Gender[1)]		Male / female	< 0.0001	0.0041
Age[1)]		10 year age groups	< 0.0001	0.28
Socioeconomic status[2)]	Highest education of the respondents' father	5 categories	0.0021	
	Highest education of the respondents' mother	5 categories	< 0.0001	
	Eriksson-Goldthorpe-Portocarero classes	6 categories	< 0.0001	< 0.0001
	Leadership, no. of subordinates	3 categories	< 0.0001	
	Highest attained education	5 categories	< 0.0001	
	Household income per adult	6 categories	< 0.0001	0.0003
	Own gross income	6 categories	< 0.0001	
Work related factors[3)]	Working hours per week	4 categories	< 0.0001	
	Overtime work	no/yes	< 0.0001	
	Only day work	no/yes	< 0.0001	
	Job tenure	single item 7 response categories	0.5308	
	Repetitive work	scale, 2 items	< 0.0001	
	Physically heavy work	scale, 2 items	< 0.0001	< 0.0001
	Job insecurity	single item 6 response categories	< 0.0001	
	Atmosphere at work	single item 6 response categories	< 0.0001	
	Satisfaction with leadership	single item 6 response categories	< 0.0001	
	Commuting	3 categories	0.24359	
	Work-family conflict	Scale, 3 items	< 0.0001	

1) Personal identification number

2) Statistics Denmark

3) Questionnaire

4) Interaction between ‘single’ and ‘children at home’

5) Interaction between ‘No of children living at home, aged 0-6’, and gender

Table 6. continued

Group of covariate	Covariate	Measure	Cross-tabulation Test for trend	Test for no effect (HR=1) final model
Personal conditions	Municipal population density of residence[2)]	4 categories	< 0.0001	0.0006
	Cohabitation[2)]	single no/yes	0.3646	0.30
	Children at home[2)]	no/yes	0.0016	0.73
	Single with children at home[4)]		-	0.012
	No. of children living at home, aged 0-6[2)]	6 categories	< 0.0001	0.016
	No.of children living at home, aged 0-6, women[5]		-	0.0007
	Number of children living at home, aged 7-17[2)]	6 categories	0.21091	
	Satisfaction with family life[3)]	single item, 6 response categories	0.3110	
	Social support from family or friends[3)]	single item, 6 response categories	0.46592	
	Taking care of home[3)]	scale, 4 items	0.0002	
	Taking care of children	scale, 4 items	0.0374	0.016
	Visits to a doctor, physiotherapist or alike of the respondents spouse[2)]	2 categories	0.0061	
	Negative affectivity[3)]	single item, 7 response categories	0.0413	< 0.0001
	Type A behaviour[3)]	single item, 7 response categories	< 0.0001	
	Self efficacy[3)]	single item, 7 response categories	0.0322	
	Worry about health[3)]	scale, 2 items	< 0.0001	
	Somatization[3)]	scale, 3 items	< 0.0001	0.0050
	Attitude to sickness absence[3)]	scale, 7 items	0.1305	
	Visits to a doctor, physiotherapist or alike[2)]	5 categories	< 0.0001	< 0.0001
	General health[3)]	single item, 5 response categories	< 0.0001	< 0.0001
	Mental health[3)]	scale, 5 items	< 0.0001	
	Musculo-skeletal pain[3)]	scale, 4 items	< 0.0001	
	Perceived stress[3)]	scale, 4 items	< 0.0001	
	Number of chronic diseases[3)]	4 categories	< 0.0001	
	Work ability[3)]	visual analogue scale	< 0.0001	
	Smoking[3)]	2 categories	< 0.0001	0.048
	Alcohol consumption[3)]	3 categories	0.0034	
	Leisure time physical activity[3)]	2 categories	0.05218	
	Body mass index[3)]	< 30 kg/m^2 , ≥ 30 kg/m^2	< 0.0001	0.0030

1) Personal identification number, 2) Statistics Denmark 3) Questionnaire, 4) Interaction between 'single' and 'children at home', 5) Interaction between 'No of children living at home, aged 0-6', and gender

Table 7
Hospital Study. Sickness absence characteristics among the total sample. By age, gender, general health, occupational group, and by the covariates of the demand-control-support and ERI-models.

	Total	Any absence	Any short spells (1-3 days)	Any medium spells (4-14 days)	Any long spells (>14 days)	"Normal" absence pattern[1)]	"Abnormal" absence pattern[2)]	Days at risk of a new absence spell[3)]	Number of absence spells per person-year at risk	Number of absence days per person per year at risk	Number of absence days in percent of all working days[3)] Group total
	N	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	mean (SD)	median	median	%
Age											
18-29	235	191 (81%)	175 (74%)	106 (45%)	22 (9%)	76 (32%)	115 (49%)	173 (64)	4.00	10	7.3
30-39	628	512 (82%)	469 (75%)	299 (48%)	41 (7%)	246 (39%)	266 (42%)	182 (62)	3.14	9	5.6
40-49	715	596 (83%)	527 (73%)	318 (44%)	69 (10%)	306 (43%)	290 (41%)	193 (55)	3.07	8	6.3
50-69	753	590 (78%)	522 (69%)	311 (41%)	77 (10%)	342 (45%)	248 (33%)	200 (47)	2.05	8	6.0
Gender											
Women	1954	1610 (82%)	1443 (74%)	884 (45%)	190 (10%)	814 (42%)	796 (41%)	190 (55)	3.07	9	6.4
Men	377	279 (74%)	250 (66%)	150 (40%)	19 (5%)	156 (41%)	123 (33%)	189 (61)	2.06	7	4.7
General health											
Fair or poor	121	106 (88%)	97 (80%)	69 (57%)	24 (10%)	38 (31%)	68 (56%)	178 (64)	5.11	13	11.3
Good, very good or excellent	2177	1757 (81%)	1573 (72%)	949 (44%)	178 (8%)	920 (42%)	836 (38%)	191 (55)	3.03	8	5.8
Occupational group											
Doctors[4)]	258	159 (62%)	149 (58%)	40 (16%)	9 (3%)	119 (46%)	40 (16%)	168 (71)	1.06	3	2.4
Physiotherapists[5)]	294	216 (73%)	207 (70%)	90 (31%)	21 (7%)	117 (49%)	99 (34%)	198 (52)	2.06	7	4.7
Nurses[6)]	710	594 (84%)	538 (76%)	305 (43%)	62 (9%)	310 (44%)	284 (40%)	191 (55)	3.07	8	5.7
Medical secretaries[7)]	328	269 (82%)	248 (76%)	149 (45%)	23 (7%)	137 (42%)	132 (40%)	191 (56)	3.01	8	5.4
Nursing assistants[8)]	491	437 (89%)	386 (79%)	290 (59%)	71 (14%)	190 (39%)	247 (50%)	191 (52)	4.05	11	9.0
Cleaners/porters[9)]	250	214 (86%)	165 (66%)	160 (64%)	23 (9%)	97 (39%)	117 (47%)	197 (50)	3.05	12	7.2
Total	**2331**	**1889 (81%)**	**1693 (73%)**	**1034 (44%)**	**209 (9%)**	**970 (42%)**	**919 (39%)**	**190 (56)**	**3.04**	**9**	**6.1 %**

Table 7 continued

Stressor (mean(SD))	Total N	Any absence n (%)	Any short spells (1-3 days) n (%)	Any medium spells (4-14 days) n (%)	Any long spells (>14 days) n (%)	"Normal" absence pattern[1] n (%)	"Abnormal" absence pattern[2] n (%)	Days at risk of a new absence spell[3] mean (SD)	Number of absence spells per person-year at risk median	Number of absence days per person per year at risk median	Number of absence days in percent of all working days[3] Group total %
Demands (3.17 (0.54))											
1.33 - <1.50	2	1 (50%)	1 (50%)	1 (50%)	0	0	1 (50%)	218 (13)	2.2	10.6	4.6
1.50 - <2.50	246	194 (79%)	175 (71%)	104 (42%)	22 (8.9%)	94 (38%)	100 (41%)	194 (54)	3.1	6.5	5.6
2.50 - <3.50	1383	1127 (81%)	1000 (72%)	628 (45%)	122 (8.8%)	593 (43%)	534 (39%)	191 (55)	3.0	7.2	6.1
3.50 - <4.50	681	549 (81%)	500 (73%)	294 (43%)	61 (9.0)	272 (40%)	277 (41%)	188 (59)	3.1	7.8	6.3
4.50 - 4.83	10	10 (100%)	10 (100%)	3 (30%)	2 (20%)	6 (60%)	4 (40%)	193 (62)	3.0	10.6	6.8
		p-trend=0.54	p-trend=0.25	p-trend=0.68	p-trend=0.75	p-trend=	p-trend=0.72				
Control (2.54 (0.58))											
1.00 - 1.50	53	41 (77%)	37 (70%)	26 (49%)	2 (3.8%)	23 (43%)	18 (34%)	205 (43)	3.0	6.0	5.3
1.50 - <2.50	1053	854 (81%)	760 (72%)	439 (42%)	83 (7.9%)	475 (45%)	379 (36%)	194 (53)	2.3	7.0	5.4
2.50 - <3.50	1058	859 (81%)	774 (73%)	486 (46%)	103 (9.7%)	403 (38%)	456 (43%)	187 (58)	3.1	8.1	6.6
3.50 - <4.50	128	100 (78%)	92 (72%)	59 (46%)	12 (9.4%)	51 (40%)	49 (38%)	181 (67)	3.0	7.5	6.8
4.50 - 5.00	6	5 (83%)	4 (67%)	3 (50%)	2 (33%)	4 (67%)	1 (17%)	146 (75)	3.3	10.7	13.8
		p-trend=0.82	p-trend=0.74	p-trend=0.10	p-trend=**0.04**	p-trend=	p-trend=**0.02**				
Support (2.24 (0.74))											
1.00 - 1.50	399	333 (83%)	304 (76%)	175 (44%)	24 (6.0%)	186 (47%)	147 (37%)	193 (52)	3.0	7.0	5.2
1.50 - <2.50	1118	897 (80%)	804 (72%)	491 (44%)	102 (9.1%)	473 (42%)	424 (38%)	191 (55)	3.0	7.0	5.9
2.50 - <3.50	657	538 (82%)	478 (73%)	307 (47%)	67 (10%)	241 (37%)	297 (45%)	188 (57)	3.1	9.0	7.0
3.50 - <4.50	118	89 (75%)	79 (67%)	50 (42%)	12 (10%)	50 (42%)	39 (33%)	186 (65)	3.0	6.5	6.1
4.50 - 5.00	8	6 (75%)	6 (75%)	0 (0.0%)	1 (13%)	3 (38%)	3 (38%)	160 (79)	3.3	5.3	4.1
		p-trend=0.29	p-trend=0.19	p-trend=0.95	p-trend=0.06	p-trend=	p-trend=0.10				
Strain (2.85 (0.33))											
1.67 - <2.50	313	261 (83%)	233 (74%)	151 (48%)	20 (6.4%)	138 (44%)	123 (39%)	195 (52)	2.8	7.0	5.7
2.50 - <3.50	1933	1554 (80%)	1390 (72%)	841 (44%)	177 (9.2%)	795 (41%)	759 (39%)	190 (56)	3.0	7.1	6.1
3.50 - <4.18	76	66 (87%)	63 (83%)	38 (50%)	10 (13%)	32(42%)	34 (45%)	177 (67)	3.5	10.0	8.2
		p-trend=0.79	p-trend=0.68	p-trend=0.48	p-trend=**0.04**	p-trend=	p-trend=0.59				
Iso-strain (2.65 (0.38))											
1.53 - <2.50	821	671 (82%)	598 (73%)	372 (45%)	62 (7.6%)	363 (44%)	308 (38%)	194 (52)	2.9	7.0	5.5
2.50 - <3.50	1458	1178 (81%)	1058 (73%)	643 (44%)	140 (9.6%)	585 (40%)	593 (41%)	189 (57)	3.1	8.0	6.4
3.50 - <3.99	45	33 (73%)	31 (69%)	16 (36%)	5 (11%)	17 (38%)	16 (36%)	169 (74)	3.1	6.0	6.1
		p-trend=0.32	p-trend=0.73	p-trend=0.33	p-trend=0.08	p-trend=	p-trend=0.24				
Total	**2331**	**1889 (81%)**	**1693 (73%)**	**1034 (44%)**	**209 (9%)**	**970 (42%)**	**919 (39%)**	**190 (56)**	**3.04**	**9**	**6.1 %**

Table 7 continued

1. Any absence, but no more than two short, one medium and one long spell, and altogether no more than three spells of any length
2. More than either two short spells, one medium spell or one long spell, or more than three spells of any length
3. Maximum 227 working days in one year.
4. Doctors, dentists, psychologists and other academic staff
5. Physiotherapists, midwives, medical laboratory technologists, social workers and alike
6. Medical secretaries, office, IT and administrative workers
7. Cleaning personal, hospital porters, and various assistants

Tabel 8. Hospital study. Final reduced models showing covariates with significant effects on different sickness absence outcomes. Gender and age, as well as other lengths of absence, are included regardless the level of significance. For each outcome, the covariates are mutually adjusted. The RR/ORs for occupational groups are shown with the group of doctors as reference. High scale values indicate the theoretically most harmful situation in relation to sickness absence.

		Short spells	Medium spells	Long spells	Abnormal absence
	Effect	RR (95% CI)	RR (95% CI)	RR (95% CI)	OR (95% CI)
Gender	Women	1.02 (0.89-1.16)	1.12 (0.92-1.36)	1.99 (1.04-3.80)	1.17 (0.85-1.61)
Age	Per 10 years	0.83 (0.80-0.87)	0.90 (0.84-0.95)	1.00 (0.83-1.21)	0.76 (0.69-0.84)
Short SA spells	Yes	-	1.41 (1.21-1.65)	1.10 (0.67-1.79)	-
Medium SA spells	Yes	1.30 (1.19-1.41)	-	2.32 (1.54-3.48)	-
Long SA spells	Yes	1.45 (1.28-1.65)	1.93 (1.64-2.27)	-	-
No special responsibilities	No	1.29 (1.13-1.48)	1.28 (1.03-1.58)		1.61 (1.20-2.17)
Role conflict	1-5		1.08 (1.01-1.15)		
Quality of leadership	1-5	1.07 (1.01-1.12)			
Violence	1-5			1.30 (1.10-1.53)	1.13 (1.00-1.28)
Full time work	1-3 3=full time	1.22 (1.14-1.30)			1.38 (1.19-1.60)
Children at home[1)]	Yes		1.03 (0.89-1.19)		
Single[1)]	Yes	1.13 (1.03-1.24)	1.09 (0.91-1.29)		0.78 (0.63-0.98)
Single with children[1)]	Yes		0.72 (0.55-0.95)		
Social support outside work	1-5		0.96 (0.92-1.00)		
General health	1-5	1.23 (1.17-1.30)	1.24 (1.15-1.34)	1.55 (1.24-1.95)	1.67 (1.48-1.88)
Occupational groups					
Doctors		1.00	1.00		1.00
Physiotherapists		1.36 (1.09-1.69)	1.94 (1.33-2.83)		2.98 (1.84-4.83)
Nurses		1.26 (0.98-1.62)	1.28 (0.83-1.97)		2.00 (1.15-3.49)
Medical secretaries		1.29 (1.02-1.64)	2.35 (1.59-3.48)		3.41 (2.03-5.72)
Nursing assistants		1.30 (1.03-1.64)	2.70 (1.84-3.96)		3.96 (2.39-6.57)
Cleaners/porters		0.69 (0.52-0.91)	3.25 (2.17-4.86)		3.03 (1.74-5.26)

1) 'Single with children' is the interaction between 'children' and 'single'. The two variables are included in the analyses of medium spells because the interaction term is significant.

Table 9. Hospital Study. Effects of occupational group on number and patterns of sickness absence spells. Results from multiple Poisson regression analyses (rate ratios (RR) and their 95% confidence intervals (CI)) of all spells, short, medium and long spells, and from multiple logistic regression analysis (odds ratios (OR) and their 95%CI) of "normal" and "abnormal" absence patterns versus no absence spells. Significant results in bold.

	All spells[1]		**Short spells** (1-3 days)[2]		**Medium spells** (4-14days)[3]		**Long spells** (>14 days)[4]		**"Normal" absence pattern**[5]		**"Abnormal" absence pattern**[6]	
	Start model	Final model	Start model	Final model	Start model	Final model	Start model	Final model	Start model	Final model	Start model	Final model
Occupational group[7]	RR	RR (95% CI)	RR	RR (95% CI)	RR	RR (95% CI)	RR	RR (95% CI)	OR	OR (95% CI)	OR	OR (95% CI)
Doctors	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Physiotherapists	**1.45**	**1.43** (1.13-1.83)	**1.39**	**1.36** (1.06-1.74)	**1.56**	1.52 (1.00-2.32)	1.19	1.03 (0.33-3.21)	1.19	1.29 (0.70-2.37)	**2.13**	**2.27** (1.07-4.83)
Nurses	**1.58**	**1.68** (1.36-2.08)	**1.35**	**1.46** (1.18-1.82)	**2.20**	**2.29** (1.59-3.30)	1.49	1.41 (0.50-3.95)	**1.98**	**2.35** (1.39-3.97)	**4.42**	**5.54** (2.87-10.7)
Medical secretaries	**1.64**	**1.72** (1.37-2.16)	**1.34**	**1.43** (1.14-1.81)	**2.65**	**2.81** (1.92-4.13)	1.10	1.06 (0.35-3.24)	1.71	**2.03** (1.12-3.67)	**4.83**	**6.31** (3.06-13.0)
Nursing assistants	**1.99**	**1.95** (1.58-2.41)	**1.43**	**1.47** (1.18-1.82)	**3.41**	**3.34** (2.33-4.80)	2.33	1.89 (0.68-5.28)	**2.54**	**2.90** (1.65-5.09)	**9.52**	**10.5** (5.30-20.8)
Cleaners/ porters	**1.52**	**1.41** (1.10-1.80)	0.83	0.79 (0.60-1.03)	**4.30**	**4.19** (2.84-6.19)	1.63	1.37 (0.45-4.13)	**2.09**	**2.43** (1.25-4.70)	**6.60**	**7.39** (3.33-16.4)
χ^2-test[8], p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.10	0.13	0.006	0.001	<0.0001	<0.0001
Mean change of estimates compared to start model		0 %		2.2 %		0.6 %		-11 %		15 %		17%

1) Start model adjusted for age, gender, work-place unit. Final model as start model and for violence, job satisfaction, weekly work hours, being single and general health.
2) Start model adjusted for age, gender, work-place unit, any medium absence, any long absence. Final model as start model and for quality of leadership, social support at work, job satisfaction, weekly work hours, being single and general health.
3) Start model adjusted for age, gender, work-place unit, any short absence, any long absence. Final model as start model and for overall demands, control, job strain, job satisfaction, being single and general health.
4) Start model adjusted for age, gender, work-place unit, any short absence, any medium absence. Final model as start model and for violence and general health.
5) Start model adjusted for age, gender, work-place unit, days at risk. Final model as start model and for overall demands, control, job strain, weekly work hours, overtime work and general health.
6) Start model adjusted for age, gender, work-place unit, days at risk. Final model as start model and for overall demands, control, job strain, weekly work hours and general health.
7) See table 7. 8) Probability of no difference between occupational groups.

Table 10. Hospital study. Return to work time among persons with sickness absence.
Absence days per year, distribution by longest duration of sickness absence spells (short, medium or long), and odds ratios (OR) with 95% confidence intervals (CI) of medium versus (vs.) short, long vs. short and long vs. medium spells, adjusted for other significant covariates in multiple logistic regression analysis (see text)[1]. Significant results in bold.

			Longest absence spell[2]			Results from logistic regression analyses, final model		
	Number of persons with any absence	Number of absence days per year	Short (1-3 days)	Medium (4 -14 days)	Long (>14 days)	Medium vs. short spells[3]	Long vs. short spells[4]	Long vs. medium spells[5]
Occupational group[5]	n	median	n (%)	n (%)	n (%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Doctors	159	3	116 (73)	34 (21)	9 (6)	1.00	1.00	1.00
Physiotherapists	216	7	117 (54)	78 (36)	21 (10)	**2.24** (1.25-4.03)	1.51 (0.58-3.96)	0.95 (0.32-2.79)
Nurses	594	8	265 (45)	267 (45)	62 (10)	**3.24** (1.94-5.40)	2.27 (0.98-5.29)	0.78 (0.29-2.07)
Medical secretaries	269	8	111 (41)	135 (50)	23 (9)	**4.49** (2.60-7.78)	2.09 (0.83-5.26)	0.58 (0.20-1.67)
Nursing assistants	437	11	131 (30)	235 (54)	71 (16)	**5.84** (3.41-9.99)	**4.25** (1.83-9.87)	0.84 (0.31-2.27)
Cleaners/porters	214	12	47 (22)	144 (67)	23 (11)	**11.2** (6.08-20.8)	**4.71** (1.82-2.19)	0.72 (0.25-2.07)
Total	1889	9	787 (42)	893 (47)	209 (11)			
X^2-test[6], p						<0.0001	0.0003	0.8151
Mean change of estimates compared to start model						6.2 %	-11.0 %	3.4 %

1) Results from start models not shown.
2) Short = only short spells. Medium = any medium but no long spells. Long = any long spells. See figure 1.
3) Start model adjusted for age, gender, work-place unit, follow-up time. Final model as start model and for overall demands, control, job strain and general health.
4) Start model adjusted for age, gender, work-place unit, follow-up time. Final model as start model and for violence and general health.
5) Start model adjusted for age, gender, work-place unit, follow-up time. Final model as start model and for violence, insecurity at work, duties and general health.
6) See table 7.
7) Probability of no difference between occupational groups,

Table 11. Hospital study. Rate ratios (RR) or odds ratios (OR) and 95% confidence intervals (CI) for effects of the demands-control-support model variables on sickness absence spells.

Multiple Poisson or logistic regression analyses. RR and OR are risk estimates for a one unit increase on scales from 1 to 5 for all variables. Model 1: Each main variable separately, no mutual adjustment. Model 2: Main variables and their interactions, mutually adjusted. Final model: Main variables and significant interactions, mutually adjusted. See footnotes on adjustment for effects of other covariates.

	All spells			**Short spells (1-3 days)**			**Medium spells (4-14 days)**			**Long spells (> 14 days)**			**Abnormal absence**		
	Model 1 [1)]	Model 2 [1)]	Final model [2)]	Model 1 [3)]	Model 2 [3)]	Final model [4)]	Model 1 [3)]	Model 2 [3)]	Final model[5)]	Model 1 [3)]	Model 2 [3)]	Final model[6)]	Model 1 [7)]	Model 2 [7)]	Final model [8)]
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Demands	1.07 (0.99-1.16)	0.76 (0.54-1.08)	1.03 (0.94-1.12)	1.08 (1.00-1.18)	0.99 (0.69-1.41)	1.09 (0.77-1.56)	1.01 (0.90-1.14)	**0.46** (0.27-0.77)	**0.58** (0.36-0.95)	1.19 (0.84-1.69)	1.39 (0.28-6.81)	1,06 (0.71-1.58)	1.04 (0.87-1.24)	**0.45** (0.21-0.96)	1,07 (0.88-1.31)
Control	**1.13** (1.05-1.22)	0.74 (0.49-1.11)	0.97 (0.89-1.06)	**1.10** (1.02-1.19)	0.99 (0.64-1-51)	1.09 (0.72-1.66)	1.08 (0.97-1.20)	**0.40** (0.22-0.74)	**0.42** (0.23-0.74)	1.19 (0.86-1.64)	1.33 (0.21-8.58)	0,96 (0.65-1.42)	**1.19** (1.02-1.40)	0.42 (0.17-1.04)	0,98 (0.80-1.19)
Support	1.06 (1.00-1.12)	0.84 (0.68-1.03)	0.97 (0.91-1.03)	1.05 (0.99-1.11)	0.82 (0.66-1.02)	**0.78** (0.63-0.97)	1.04 (0.96-1.13)	1.01 (0.75-1.38)	0,96 (0.87-1.05)	1.21 (0.95-1.55)	1.14 (0.44-2.94)	1,15 (0.86-1.53)	1.08 (0.96-1.23)	0.99 (0.61-1.60)	0,99 (0.86-1.15)
Strain[9)]		1.54 (0.72-3.29)	-		0.92 (0.42-2.02)	0.64 (0.29-1.40)		**4.75** (1.52-14.84)	**3,31** (1.32-8.33)		0.76 (0.02-24.27)	-		5.00 (0.93-26.94)	-
Isostrain[10)]		1.81 (0.98-3.35)	-		1.88 (0.99-3.55)	**1.94** (1.04-3.61)		1.02 (0.41-2.53)	-		1.14 (0.07-17.32)	-		1.15 (0.28-4.78)	-

1) Adjusted for age, gender and work unit. 2) As 1) and SES, special duty responsibilities, violence, job satisfaction, full time work, being single and general health. 3) As 1), and absences of other lengths. 4) As 3) and SES, special duty responsibilities, job satisfaction, full time work, being single and general health. 5) As 3) and SES, special duty responsibilities, job satisfaction, being single and general health. 6) As 3) and special duty responsibilities and general health. 7) As 1), and days at risk. 8) As 7) and SES, special duty responsibilities, full time work, being single and general health. 9) Multiplicative interaction term demands x control / 5, see 'Methods'. 10) Multiplicative interaction term demands x control x support / 25, see 'Methods'

Covariate		Score	Total	Any sickness absence >14 days	
			N	n	%
Demands	low	1	80	5	6.3
		2	693	57	8.2
		3	2544	259	10.2
		4	5517	581	10.5
		5	4119	487	11.8
	high	6	1160	166	14.3
		Total	14113	1555	11.0
Control	high	1.0 - <1.5	1332	120	9.0
		1.5 - <2.5	5735	503	8.8
		2.5 - <3.5	4055	475	11.7
		3.5 - <4.5	1689	238	14.1
		4.5 - <5.5	717	129	18.0
	low	5.5 - 6.0	348	63	18.1
		Total	13876	1528	11.0
Support	high	1.0 - <1.5	2480	262	10.6
		1.5 - <2.5	4115	390	9.5
		2.5 - <3.5	3575	397	11.1
		3.5 - <4.5	1946	241	12.4
		4.5 - <5.5	1229	165	13.4
	low	5.5 - 6.0	678	89	13.1
		Total	14023	1544	11.0
Strain	low	1.0 - < 1.5	13	0	0.0
		1.5 - < 2.5	681	57	8.4
Mean of demands and control		2.5 - < 3.5	7487	684	9.1
		3.5 - < 4.5	4837	609	12.6
		4.5 - < 5.5	737	152	20.6
	high	5.5 – 6.0	109	24	22.0
		Total	13864	1526	11.0
Iso-strain	low	1.0 - <1.5	20	1	5.0
		1.5 - <2.5	2129	173	8.1
Mean of strain and support		2.5 - <3.5	7764	772	9.9
		3.5 - <4.5	3216	446	13.9
		4.5 - <5.5	593	115	19.4
	high	5.5 - 6.0	41	6	14.6
		Total	13763	1513	11.0
Effort	low	1.0 - <1.5	2043	179	8.8
		1.5 - <2.5	5172	496	9.6
		2.5 - <3.5	4199	438	10.4
		3.5 - <4.5	2086	306	14.7
	high	4.5 - 5.0	450	99	22.0
		Total	13950	1518	10.9
Reward	high	1.0 - < 1.5	4415	362	8.2
		1.5 - < 2.5	5569	591	10.6
		2.5 - < 3.5	2826	368	13.0
		3.5 - < 4.5	1000	170	17.0
	low	4.5 - 5.0	112	18	16.1
		Total	13922	1509	10.8
ERI	low	0.2 - <0.5	5148	451	8.8
		0.5 - <1.0	6032	618	10.2
		1.0 - <1.5	1751	253	14.5
		1.5 - <2.0	590	101	17.1
		2.0 - <2.5	182	44	24.2
		2.5 - <3.5	119	24	20.2
	high	3.5 - 5.0	32	7	21.8
		Total	13854	1498	10.8
Overcommitment	low	1.0 - <1.5	2004	182	9.1
		1.5 - <2.5	6439	660	10.3
		2.5 - <3.5	4687	570	12.2
	high	3.5 - 4.0	932	132	14.2
		Total	14062	1544	11.0

Table 12 ASUSI study Distribution of sickness absence by demand-control-support and effort-reward-imbalance model variables. High values indicate factors supposed to be related to more sickness absence, e.g. low control.

Table 13. ASUSI study. Effects of the demand-control-support and the effort-reward-imbalance (ERI) model variables. Hazard ratios (HR) and 95% confidence intervals (CI) for a one unit increase of covariates. Significant results are shown in bold.
ns=not significant.

	Range of scores	**Model 1**		**Model 2**		**Final Model**	
		HR (95% CL)	P-value	HR (95% CL)	P-value	HR (95%CL)	P-value
Demand-control-support model							
Demands	1-6	**1.13** (1.07-1.19)	<.0001	1.13 (1.00-1.28)	0.058	1.00 (0.87-1.16)	0.96
Control	1-6	**1.27** (1.22-1.32)	<.0001	1.19 (1.00-1.42)	0.049	0.95 (0.77-1.16)	0.59
Strain (demands x control)	1-36	-		1.044 (0.998-1.093)	0.063	1.048 (0.994-1.105)	0.085
Support	1-6	**1.09** (1.05-1.13)	<.0001	1.08 (0.99-1.18)	0.073	1.04 (0.95-1.15)	0.42
Iso-strain (strain x support)	1-216	**-**		**0.9936** (0.9874-0.9998)	0.042	**0.9921** (0.9851-0.9992)	0.029
ERI model							
ERI	0.20-5.00	**2.14** (1.69-2.71)	<.0001	**1.69** (1.20-2.39)	0.0029	**1.74** 1.31-2.31	<.0001
ERI x ERI	0.04-25.0	**0.90** (0.84-0.97)	0.0053	**0.88** (0.81-0.96)	0.0026	**0.90** 0.83-0.98	0.015
Overcommitment	1-4	**1.16** (1.08-1.24)	<.0001	0.94 (0.82-1.07)	0.34	ns	-
ERI x overcommitment	0.20-20.0	-		1.118 (0.982-1.272)	0.093	ns	-

Model 1: No interaction terms. No mutual adjustment. Adjusted for age and gender.

Model 2: Mutually adjustment, separately for demand-control-support and ERI variables. Adjusted for age and gender.

Final model: Mutual adjustment of demand-control-support and ERI variables in the same model.
Adjusted for age and gender.
Adjusted for all significant covariates:
SES (Eriksson-Goldthorpe-Portocarero class.), household income per adult, cohabitation, children, inter-action of cohabitation and children, taking care of children, negative affectivity, somatisation, BMI, smoking, population density, general health, no. of weeks in 2004 with visits to a doctor, physically strained work.

Tabel 14. ASUSI study. Final reduced models showing covariates with significant effects on sickness absence spells > 14 days. Gender and age are included regardless the level of significance. The final model also included the demand-control-support and ERI variables shown in the final model in table 13. All covariates are mutually adjusted. Significant results are shown in bold.

Covariate	Level	Sickness absence spells > 14 days		Test for difference
		HR	95% CI	p
Gender	women compared to men	**1.22**	1.07-1.40	0.0041
Age	18-29 years	1.00		0.28
	30-39 years	1.22	0.96-1.54	
	40-49 years	1.24	0.98-1.57	
	50-59 years	**1.29**	1.03-1.63	
	60-64 years	1.22	0.88-1.69	
SES	managerial	1.00		<0.0001
	low managerial	1.13	0.89-1.44	
	routine, clerical	1.00	0.76-1.33	
	routine, sales	1.09	0.81-1.46	
	skilled worker	**1.55**	1.17-2.06	
	unskilled worker	**1.65**	1.27-2.14	
	self-employed	**1.43**	1.04-1.97	
Household income per adult	0-19.000 euro / year	1.00		0.0003
	20-29.000 euro / year	1.33	0.97-1.81	
	30-39.000 euro / year	1.06	0.78-1.44	
	40-49.000 euro / year	0.99	0.72-1.35	
	50-59.000 euro / year	0.85	0.59-1.22	
	≥ 60.000 euro / year	0.70	0.47-1.04	
General health	excellent	1.00		<0.0001
	very good	1.06	0.85-1.31	
	good	**1.48**	1.20-1.83	
	fair	**1.86**	1.44-2.41	
	poor	**1.90**	1.20-3.02	
No. of weeks in 2004 with visits to a doctor or other practitioners	0	1.00		<0.0001
	1-2 weeks	**1.77**	1.29-2.43	
	3-5 weeks	**2.41**	1.77-3.26	
	6-10 weeks	**3.57**	2.64-4.84	
	> 10 weeks	**4.87**	3.57-6.63	
Single[1)]	yes	0.92	0.78-1.08	0.3037
Children[1)]	yes	1.03	0.86-1.24	0.7306
Single with children[1)]	yes	**1.51**	1.10-2.08	0.0101
Taking care of children	0-4	0.92	0.85-0.98	0.0177
Negative affectivity	1-7	**0.90**	0.86-0.95	<0.0001
Somatisation	1-5	**1.13**	1.04-1.24	0.0045
Body mass index	≥ 30 kg/m^2	**1.27**	1.09-1.49	0.0023
Smoking	yes	**1.13**	1.00-1.27	0.0466
Population density	1-4	**0.85**	0.77-0.93	0.0006
Physical strained work	1-4	**1.40**	1.20-1.63	<0.0001

1) 'Single with children' is the interaction between 'children' and 'single'. The two variables are included in the analyses because the interaction term is significant.

Appendix 1

Systematic reviews of the literature

The objectives of the systematic searches were to answer the questions:

1) Does exposure to job strain (defined from measures of job demands and job control) increase the risk of subsequent sickness absence?
2) Does exposure to effort-reward imbalance increase the risk of sickness absence?
3) Is there an association between socioeconomic status and sickness absence?

The inclusion criteria depended on the subject. In case of very comprehensive literature on the subject, the inclusion criterions were strict, and vice versa.

The inclusion criteria for objective 1) were prospective studies in a healthy population calculating job strain from measures of demands and control and with follow-up data on objective registered sickness absence. The job strain model was presented in 1979, so searches were limited to studies published in 1979 or later. Return to work studies were excluded.

The inclusion criteria for objective 2) were all studies examining the association between effort-reward imbalance and sickness absence. The effort-reward questionnaire was introduced in 1996, so searches were limited to studies published in 1996 or later. Return to work studies were excluded.

The inclusion criteria for objective 3) were all studies examining the association between socioeconomic status and sickness absence. No limit was set for publication dates. Return to work studies were excluded.

Searches were conducted as electronic searching of bibliographic databases, hand searching of journals and reading through reference lists of the relevant articles retrieved from the electronic searches and from the hand searches. Moreover articles found by chance were included in the review.

Searches were conducted in PubMed, Embase, Web of Science and PsycInfo. Furthermore hand searches were conducted from 2005 to May 2009 in the following journals: Occupational and Environmental Medicine, Journal of Occupational and Environmental Medicine, International Archives of Occupational and Environmental Health, Scandinavian Journal of Work, Environment and Health, American Journal of Industrial Medicine. The four latter journals were in 2000 reported as 4 out of 5 journals containing the most information on occupational health problems.[180] From February 2008 to May 2009 electronic tables of contents from the following journals have been hand searched: Archives of environmental & occupational health, Occupational Medicine (Oxford), Journal of Occupational and Environmental Hygiene, Environmental Health Perspectives, International

Journal of Occupational and Environmental Health, International Journal of Epidemiology, American Journal of Epidemiology, Journal of Epidemiology and Community Health, and Work.
These rather comprehensive searches have been done because it is the only way to get the most important part of the published articles. No database is exhaustive. PubMed is the largest, but is in no way covering all published work concerning occupational health.[181] The majority of journals are not indexed in the databases, and some sections of the indexed journals might not be included in the database. Moreover, even in very sensitive and "correctly" conducted database searches, only a part of the relevant references are identified. The percentage of identified references in a database will vary with the topic under investigation. Surveys on the qualities of search strategies and keywords have been conducted concerning different subjects, e.g. return-to-work,[182] but to my knowledge, no such surveys have been published concerning database searches of sickness absence, psychosocial work environment or socioeconomic status. Therefore it is not possible to estimate, how many references could be "missing".
The titles and abstracts of the retrieved references were screened to identify studies which were potentially eligible for inclusion, and full copies of these articles were obtained. Finally the full articles were assessed to determine if they met the inclusion for the review. No further quality criteria were required.
Only articles in English were included. However abstract of articles in other languages were scrutinized to get an idea of the amount of all literature in the field and full copies of articles in French, Swedish, Norwegian or Danish were obtained, if possible. Few articles in other languages than English were of interest and in the final review they were excluded.

The full search strategies

The different search strings include keywords from the thesaurus of the databases[c] and free text words. Before the final search string were completed, the searches were modified several times, as new text words occurred from the literature; and new thesaurus keywords assigned to key articles have also been added. So the searches have been currently up-dated with final searches in May 2009.

[c] Web of Science has no thesaurus

The following electronic searches were conducted:

PubMed[d]

#1, sickness absence[e]

"Sick Leave"[Mesh] OR "Absenteeism"[Mesh] OR "sick leave*"[All Fields] OR "absenteeism"[All Fields] OR "sickness absence*"[All Fields] OR "sickness leave*"[All Fields] OR "sick absence*"[All Fields] OR "days off work"[All Fields] OR "Work Absence*"[All Fields] OR (Absence*[All Fields] AND "work"[Mesh]) OR (sick list[All Fields] OR sick listed[All Fields] OR sick listing[All Fields] OR sick listings[All Fields] OR sick lists[All Fields]) OR "work loss*"[All Fields]
10.888 references on May 22nd 2009

#2, job strain

(("demand-control model"[All Fields] OR "job strain"[All Fields] OR "iso strain"[All Fields] OR karasek[All Fields]) OR (("job demand"[All Fields] OR "work demand"[All Fields]) AND ("job control"[All Fields] OR "work control"[All Fields] OR "decision latitude"[All Fields] OR "skill discretion"[All Fields] OR "decision authority"[All Fields])) OR ("Social Support"[Mesh] AND ("Work"[Mesh] OR "Occupations"[Mesh])) OR ("Stress, Psychological "[Mesh] AND ("Work"[Mesh] OR "Occupations"[Mesh])) OR (stressor[All Fields] AND ("Work"[Mesh] OR "Occupations"[Mesh]))) AND "humans"[MeSH Terms] AND ("1979"[PDAT] : "3000"[PDAT])
2.407 references on May 31st 2009

#3, effort-reward imbalance

((("effort reward*"[All Fields] OR overcommitment[All Fields] OR siegrist[All Fields]) OR ("Stress, Psychological "[Mesh] AND ("Work"[Mesh] OR "Occupations"[Mesh])) OR (stressor[All Fields] AND ("Work"[Mesh] OR "Occupations"[Mesh]))) AND "humans"[MeSH Terms] AND ("1996"[PDAT] : "3000"[PDAT]))
1.308 references on May 31st 2009

[d] [All fields] indicate search in title and abstract

[e] Comments: Using only the two Mesh -terms for sickness absence retrieved 7.763 references, the search string ("Sick Leave"[Mesh] OR "Absenteeism"[Mesh] OR "sickness absence*"[All Fields]) retrieved 7.969 references on May 22nd 2009, whereas the above search string including more free text words retrieved 10.888 references. (See figure 1.1.) Several relevant references would have been missed if the search had not included the free text words. ("sick list*") was replaced by derivations because some references were missed otherwise, of unknown reasons. (Absence*[All Fields] AND "work"[All Fields]) was excluded from the search string because including this retrieved too many irrelevant references. Including the search string retrieved 20.804 references instead of 10.888 references because "work" and "absence" are common words used in other contexts. Including the limit "Humans" in this search resulted in exclusion of relevant articles and was therefore not used.

#4, socioeconomic status

"Social Class"[Mesh] OR "Socioeconomic Factors/classification"[Mesh] OR "Occupations/classification"[Mesh] OR "Employment/classification"[Mesh] OR "Income/classification"[Mesh] AND "Socioeconomic status"[All Fields] OR "SES"[All Fields] OR "Occupational class"[All Fields] AND "humans"[MeSH Terms]
6156 references on May 25th 2009

#5, #1 AND #2 *101 references on May 31st 2009*
#6, #1 AND #3 *55 references on May 31st 2009*
#7, #1 AND #4 *30 references on May 25th 2009*

Embase[f]

#1, sickness absence

Absenteeism/ OR absenteeism.mp. OR "sick leave".mp. OR "sickleave".mp. OR "sickness absence".mp. OR "sickness leave".mp. OR "sick absence".mp. OR "days off work".mp. OR "work absence".mp. OR "sick list*".mp. OR "work loss".mp.
limit to adult <18 to 64 years>
limit to human
3.450 references on May 26th 2009

#2, job strain

Job Stress/ OR (stressor.mp. AND (exp "occupation and occupation related phenomena"/ OR occupation/ OR occupational health/ OR work/ OR work environment/)) OR "demand control model".mp. OR "job strain".mp. OR "iso strain".mp. OR karasek.mp. OR (("job demand".mp. OR "work demand".mp.) AND ("job control".mp. OR "work control".mp. OR "decision latitude".mp. OR "skill discretion".mp. OR "decision authority".mp.))
limit to (human and yr="1979 -Current" and adult <18 to 64 years>)
1.290 references on June 12th 2009

[f] Emtree words are indicated with a slash after the keyword, mp indicate search in: title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name

#3, effort-reward imbalance

Job Stress/ OR (stressor.mp. AND (exp "occupation and occupation related phenomena"/ OR occupation/ OR occupational health/ OR work/ OR work environment/)) OR "effort reward*".mp OR overcommitment.mp OR siegrist.mp
limit to (human and yr="1996 -Current" and adult <18 to 64 years>)
958 references on June 12th 2009

#4, socioeconomic status

social status/ OR social class/ OR socioeconomics/ OR "socioeconomic status".mp. OR "social class".mp. OR "SES".mp. OR "occupational class".mp. OR "occupational group".mp.
limit to human
52.402 references on May 26th 2009

#5, #1 AND #2	*103 references on June 12th 2009*
#6, #1 AND #3	*84 references on June 12th 2009*
#7, #1 AND #4	*233 references on May 26th 2009*

Web of Science

#1, sickness absence

TS=(absenteeism OR "sick leave" OR "sickness absence" OR "sickness leave" OR "sick absence" OR "days off work" OR "work absence" OR "sick list*" OR "work loss")
6.036 references on May 26th 2009

#2, job strain

TS=("demand-control model" OR "job strain" OR "iso strain" OR karasek OR (("job demand" OR "work demand") AND ("job control" OR "work control" OR "decision latitude" OR "skill discretion" OR "decision authority")) OR (stressor AND (work OR occupations)))
Timespan=1979-2009
1878 references on June 12th 2009

#3, effort-reward imbalance

TS=("effort reward*" OR overcommitment OR Siegrist OR (stressor AND (work OR occupations)))
Timespan=1996-2009
822 references on June 12th 2009

#4, socioeconomic status

TS=("socioeconomic status" OR "social class" OR "SES" OR "occupational class" OR "occupational group")
30.637 references on May 26th 2009

#5, #1 AND #2 *131 references on June 12th 2009*
#6, #1 AND #3 *51 references on June 12th 2009*
#7, #1 AND #4 *116 references on May 26th 2009*

PsycInfo

#1, sickness absence

Absenteeism/ OR absenteeism.mp. OR "sick leave".mp. OR "sickleave".mp. OR "sickness absence".mp. OR "sickness leave".mp. OR "sick absence".mp. OR "days off work".mp. OR "work absence".mp. OR "sick list*".mp. OR "work loss".mp.
limit to (320 young adulthood <age 18 to 29 yrs> or 340 thirties <age 30 to 39 yrs> or 360 middle age <age 40 to 64 yrs>)
limit to human
564 references on May 26th 2009

#2, job strain

exp Occupational Stress/ OR "demand control model".mp. OR "job strain".mp. OR "iso strain".mp. OR karasek.mp. OR (("job demand".mp. OR "work demand".mp.) AND ("job control".mp. OR "work control".mp. OR "decision latitude".mp. OR "skill discretion".mp. OR "decision authority".mp.)
limit to (human and (320 young adulthood <age 18 to 29 yrs> or 340 thirties <age 30 to 39 yrs> or 360 middle age <age 40 to 64 yrs>) and yr="1979 -Current")
1.777 references on June 12th 2009

#3, effort-reward imbalance

exp Occupational Stress/ OR "effort reward*".mp OR overcommitment.mp OR siegrist.mp
limit to (human and (320 young adulthood <age 18 to 29 yrs> or 340 thirties <age 30 to 39 yrs> or 360 middle age <age 40 to 64 yrs>) and yr="1996 -Current")
1.705 references on June 12th 2009

#4, socioeconomic status

social status/ OR social class/ OR socioeconomics/ OR "socioeconomic status".mp. OR "social class".mp. OR "SES".mp. OR "occupational class".mp. OR "occupational group".mp.
limit to human
31.985 references on May 26th 2009

#5, #1 AND #2 *80 references on June 12th 2009*
#6, #1 AND #3 *79 references on June 12th 2009*
#7, #1 AND #4 *23 references on May 26th 2009*

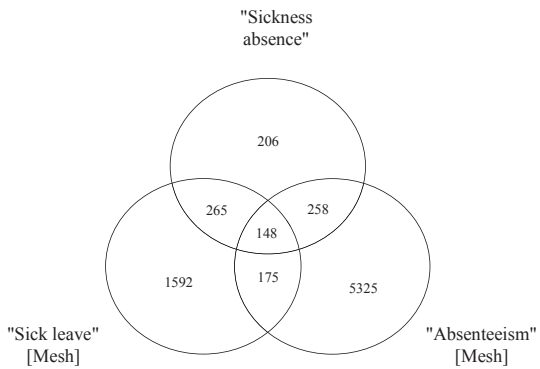


Figure 1.1
The number of retrieved references, and overlap of retrieved references using different keywords in PubMed. The search string ("Sick leave"[Mesh] OR "Absenteeism"[Mesh] OR "sickness absence") retrieved 7969 references.

Appendix 2

Overall demand scale (Cronbach α: 0.81)

Quantitative demands (workload) (Cronbach α: 0.68)

Do you have to work very fast? *
Is your workload unevenly distributed so it piles up? *
How often do you not have time to complete all your work tasks? *
Do you have to do overtime? *

Cognitive demands (Cronbach α: 0.75)

Do you have to keep your eyes on a lot of things while you work? *
Does your work require that you remember a lot of things? *
Does your work demand that you are good at coming up with new ideas? *
Does your work require you to make difficult decisions? *

Emotional demands (Cronbach α: 0.82)

Does your work put you in emotionally disturbing situations? *
Is your work emotionally demanding? **
Do you get emotionally involved in your work? **

Control scales (Cronbach α: 0.78)

Decision authority (In COPSOQ labelled "Influence at work") (Cronbach α: 0.77)

Do you have a large degree of influence concerning your work? *
Do you have a say in choosing who you work with? *
Can you influence the amount of work assigned to you? *
Do you have any influence on how you do your work? *
Do you have any influence on what you do at work? *

Skill discretion (In COPSOQ labelled "Possibilities for development") (Cronbach α: 0.73)

Is your work varied? *
Does your work require you to take the initiative? **
Do you have the possibility of learning new things through your work? **
Can you use your skills or expertise in your work? **

Social support (Cronbach α: 0.81)

How often do you get help and support from your colleagues? *
How often are your colleagues willing to listen to your work related problems? *
How often do you get help and support from your immediate superior? *
How often is your immediate superior willing to listen to your work related problems? *
Can you get the professional support you need from your colleagues or from your superior? * [1)]

[1)] One item in the social support scale did not come from the COPSOQ

Response categories:

* Always/ often/ sometimes/ seldom/ never/ hardly ever

** To a very large extent/ to a large extent/ somewhat/ to a small extent/ to a very small extent

Demand - single item

”How demanding do you feel your work is, all in all?”

(Extremely demanding/ very demanding/ quite demanding/ fairly demanding/ not very demanding/ hardly demanding at all)

Decision authority - single item

”How much influence do you normally have on the organisation and execution of your work?

(A lot/ quite a lot/ moderate/not very much/ rather little/ very little)

Skill discretion – single item

“Do you find your work stimulating, educational and involving?”

(To a very great extent/ to a great extent/ to some extent/ to a lesser extent/ to a very little extent/ hardly at all)

Social support – single items

“If you have problems with your work, can you obtain the necessary help and support from management?”

“If you have problems with your work, can you obtain the necessary help and support from your colleagues?”

(Always / almost always / usually / often / now and again / rarely, never)

Effort scale (Cronbach α: 0.76)

How well do the following statements apply to you?

I am under constant pressure of time due to a heavy workload. *
I am often interrupted and disturbed in my work. *
In recent years, my work has become more and more demanding. *

Reward scale (Cronbach α: 0.80)

How well do the following statements apply to you?

I have experienced, or expect to experience, unwanted changes in my work. *
I am greatly at risk of being fired. *
I have poor prospects for promotion. *
I receive the respect I deserve from my superiors. **
When you take all my efforts and my performance into account, I receive all the respect and prestige I deserve in my work. **
My future prospects at work are in proportion to my efforts and performance. **
My salary/income is in proportion to my efforts and performance at work. **

Response categories:

* Agree, it doesn't bother me/ agree, it bothers me slightly/ agree, it bothers me somewhat/ agree, it bothers me a lot

* *Disagree, it doesn't bother me/ disagree, it bothers me slightly/ disagree, it bothers me somewhat/ disagree, it bothers me a lot

Overcommitment scale (Cronbach α: 0.78)

How well do the following statements apply to you?

I am often short of time when I work.
When I wake up, the first thing I think of is often my work.
When I get home from work, it is easy for me to relax and let go.
People who know me well say I make too many sacrifices for my work.
I am never finished with my work. Even in the evenings, I often think about it.
If I postpone something I should have done today, I have trouble sleeping at night.

Response categories:

Strongly disagree/ partially disagree/ partially agree/ totally agree

Effort single item

”Do you have sufficient time and resources to perform your tasks satisfactorily?”

Reward single item

”Do you feel your work efforts are sufficiently appreciated?”

Overcommitment single item

”Do you feel such an obligation and commitment to your work that you have difficulty letting go when you come home?”

Response categories:

To a very great extent/ to a great extent/ to some extent/ to a lesser extent/ to a very little extent/ hardly at all

Appendix 3

Validation study:

Psychosocial work environment: Can job demands and job control be measured with single items?

ABSTRACT

Objectives: To examine if four global single items measuring job demands (overall job demands and workload) and control (decision authority and skill discretion) could be valid alternatives to multi-item scales measuring the same constructs.

Methods: Questionnaires used in three cross sectional hospital studies included both global single items and multi-item scales measuring workload, decision authority and skill discretion. One study also included items on overall job demands. The relation between each of the global single items and the corresponding multi-item scales were examined by Spearman correlation coefficients calculated for each of the three hospitals. Further, Spearman correlations of corresponding global single items and multi-item scales with 33 other study variables were compared by regression analyses and graphical plots of corresponding correlation coefficients.

Results: Correlations between global single items and multi-item scales were moderate to high. Correlations with 33 other variables were generally very similar for global single items and multi-item scales.

Conclusion: The corresponding global single items and multi-item scales used in this study seem to be comparable (similar, alternative??) measures of the same constructs.

INTRODUCTION

Traditionally, multi-item scales are preferred to global single items as measures of complex constructs such as the psychosocial work environment. Multi-item scales are considered to be more stable, reliable and precise than single items [183] . However, global single items have many attractive properties compared to multi-item scales.

The psychosocial work environment is characterized by many dimensions (e.g. demands, control, social support, effort, reward and job satisfaction), and when each dimension is measured by typically 5-10 items, questionnaires on the topic tend to become rather long, often with more than 100 items [98;184-186]. Long questionnaires may increase the number of non-responders, and among responders many similar items on the same topic may lead to inaccurate or missing responses. Furthermore, in surveys with focus on other topics than the psychosocial work environment, the inclusion of more than a few psychosocial

multi-item scales in the questionnaire may seriously increase the length of the questionnaire, distort the balance of its contents and result in a wrong impression of the study focus. These drawbacks could be avoided if multi-item measures were replaced by appropriate global single items measuring the same construct. In addition, global single items scores are easier to interpret than scale scores derived from a diversity of combinations of item scores. In our opinion, however, the most important advantage of global single items is that the essential parts of the construct are selected and weighted by the respondent and not by the researcher.

We have previously developed a short indoor climate questionnaire [96]. We wanted to include questions about the psychosocial work environment since it could influence indoor climate symptoms. However, standard multi-item measures of even a few dimensions soon filled more than the core questions on indoor climate, and since there were no validated global single items, excluding job satisfaction [187], we therefore developed a set of global single items to cover various dimensions of the psychosocial work environment. We have used these and other global single items in later research together with corresponding multi-item measures of the same construct.

The present study compares four of these global single items (SI) with corresponding multi-item scales (MI), covering dimensions from Karasek's job strain model [38]. According to this model, job strain is a result of the interaction between job demands and job control. Karasek developed the Job Content Questionnaire, JCQ [188], where psychological demands (one scale) and control (with two subscales, decision authority and skill discretion) were measured with 9 items each. Many studies have examined the relations between demands, control or strain and especially future heart disease [70;189] and poor mental health [42;43].

We compare SI and MI measures of two aspects of job demands, "overall demands" and "workload", and of the two sub dimensions of job control, "decision authority" and "skill discretion". And we compare SI and MI measures of "job strain", a combined measure of job demands and job control.

METHODS

The material consist of data from questionnaire surveys on the psychosocial work environment of three Danish hospital populations: 1) all employees at a general hospital in the county of Copenhagen, including somatic and psychiatric departments and all supporting staff (Hospital I); 2) all employees engaged in treatment and care of patients at a psychiatric hospital in Århus (Hospital II); and 3) all employees in two somatic centres at the Danish National Hospital, including secretaries and administrative staff but not other non-care auxiliary staff (Hospital III). Basic information about the studies is shown in table 1. The questionnaires used in Hospital II and III were identical and differed

from the questionnaire used in Hospital I by having fewer job demands subscales. The survey questionnaires included SIs as well as MIs measuring overall demands (only Hospital I), workload, decision authority and skill discretion. The questionnaires used in Hospital II and III did not include MIs about cognitive and emotional demands, and therefore, an overall demand scale could not be constructed for these studies.

Global single items (SI) measuring job demands and control

The SIs appeared together as one section at the end of the questionnaires with the heading "Overall valuation of your work".

The wordings of the SIs were: 1) overall job demands: "*How demanding do you feel your work is all in all?*", with six response categories ("extremely demanding" to "hardly demanding at all"); 2) workload: "*How heavy do you feel your workload is?*" with six response categories ("extremely heavy" to "very light"); 3) decision authority: "*How much influence do you normally have on the organisation and execution of your work?*" with six response categories ("a lot" to "very little"); 4) skill discretion: "*Do you find your work stimulating, educational and involving?*" with six response categories ("to a very great extent" to "hardly at all"). All responses were scored 1-6, a high score indicating high demands, low decision authority or low skill discretion. A SI-measure of control was constructed as the mean of SI-decision authority and SI-skill discretion.

Multi-item scales (MI) measuring job demands and job control

MIs measuring demands and control were from the first edition of the Copenhagen Psychosocial Questionnaire, COPSOQ [101], which in part were based on the scales from the Whitehall II study [190]. The scale on overall job demands covered quantitative demands (= workload) (4 items), cognitive demands (4 items) and emotional demands (3 items). The control scale covered decision authority (5 items) and skill discretion (4 items). All items had five verbally anchored response categories from a low to a high degree, scored 1 to 5, a high score indicating high demands, low decision authority or low skill discretion. The scales were placed in the beginning of the questionnaires. The wordings of the items are shown in the *Appendix.*

Each of the three demand dimensions and the two control dimensions were measured as the mean of their item scores. A combined demand scale, "overall demands", was constructed by taking the mean of the three demand scales. A measure of control was similarly constructed as the mean of the two control scales. Cronbach α of the scales appear from table 2. If half or more of the items in a scale were missing the scale was coded as missing.

Job strain measures

In Karasek's job strain model, the "job strain" concept is defined as the combination of high job demands and low control, based on undefined dichotomies of the scales. In the present study we defined SI and MI job strain measures as the mean of the corresponding SI and MI demand and control measures.

Other variables

Other variables used in this study were measured identically in the two questionnaires. The questionnaires included questions about job seniority, number of working hours per week, overtime, sickness presence (going to work being sick) and sickness absence the previous 12 months (days and spells). Scales measuring meaning of work (2 items), commitment to work (4 items), predictability (2 items), sense of community (3 items) and role-clarity (4 items) came from the first edition of the Copenhagen Psychosocial Questionnaire, COPSOQ [101]. Global single items about other work characteristics ("sufficient time and resources", "responsibility at work", "psychological working climate", "feeling like going to work", "stressful work" and "job satisfaction"), about personality ("type A behaviour", "negative affectivity", "self efficacy") and about "support from family and friends" were developed together with the SIs measuring demands and control. A single item measuring self rated health and scales measuring vitality (4 items) and mental health (5 items) were from the SF-36 [191]. Single items about low back pain and sickness absence due to low back pain during the last 12 month were from the NUDATA study [192].

The studies were reported to The Danish Data Protection Agency. According to Danish law, research projects based only on questionnaires do not need permission from an ethics committee.

Analysis

We hypothesized that each SI measures the same construct as the corresponding MI. The SI must then be positively associated with the MI, and their associations with other variables should be similar, except for the scale of measurement.

The relation between each of the SIs and the corresponding MIs were examined by Spearman correlation coefficients calculated for each of the three hospitals. Further, Spearman correlations were calculated between the corresponding SI/MI and 33 other variables, with which we expected the correlations to be low (e.g. gender, age, pain) as well as moderate to high (e.g. job satisfaction, quality

of management, responsibility at work). The 33 pairs of correlation coefficients for each set of SI/MI were examined visually from plots of the corresponding correlation coefficients, and by regression analysis of SI-correlations on MI-correlations. The analyses were made separately for each hospital. The adjusted R^2 of these regression analyses were used as a formal measure to describe the degree of association between the two sets of correlation coefficients.
All data were analysed using SAS 9.1.

RESULTS

Correlations between the SI and MI for each dimension are shown in table 2. For overall demands the correlation coefficient was 0.51 (only measured in Hospital I). For work load the correlations were between 0.48 and 0.55; for decision authority between 0.53 and 0.57; for skill discretion between 0.50 and 0.67, for control between 0.59 and 0.69 and for strain between 0.49 and 0.53 (not shown in table 2). All the other correlations shown in table 2 were as accepted inferior to those of the SI/MI pairs.
As an illustration of the results, the correlations between workload/control and 33 other variables are shown in table 3. (Data not shown for decision authority, skill discretion and strain.) Generally these correlations were quite similar for SI and MI. However, for a few variables there were consistent and relatively large differences in all three datasets between the SI correlation and the MI correlation. This was the case for "overtime" and "responsibility at work" correlations with demand variables, and for "feeling like going to work" and "job satisfaction" correlations with control variables.
As an example, data from Hospital I are shown in figure 1 as plots of the corresponding SI and MI correlations with other variables. The two graphs for overall demands and control are based on the correlations showed in table 3. The relationships between the SI/MI correlations were obviously linear. Plots from Hospital II and III are not shown, but looks very similar. Parameters for the regression lines and the adjusted R^2 for all the dimensions are shown in table 4. In all cases the intercept (α) is almost 0.00, the slope (β) is close to unity and adjusted R^2 varied between 0.78 and 0.97 (mean 0.88).
Finally it should be mentioned, that the SI and the MI correlations with other variables were distributed as expected: the correlations with gender, age and low back pain were low and the correlations with other work environment factors were moderate to high.

DISCUSSION

We wanted to examine if the SIs measuring job demand and job control dimensions may be assumed to measure the same construct as the corresponding MI scales. If so, the two measures should be

positively correlated. .We found that the Spearman correlation coefficients between corresponding SI/MI measures were moderate to high (r_s = 0.48-0.69) and higher than with non-corresponding SIs/MIs (table 2). Both measures may be assumed to measure the underlying construct with some random error, and most likely also with some systematic error. Without a true and unambiguous gold standard these measurement inaccuracies cannot be scrutinized objectively. One of the two measures may be superior to the other by certain criteria, but this cannot be decided on without objective criteria.

Furthermore, if the SI and corresponding MI measure the same construct, their correlations with other variables should be similar over a range of variables with assumedly different degrees of associations with the underlying construct. In fact, we found a remarkably consistent pattern of these associations for all corresponding SI/MIs. One could argue that similar correlations may be found for very different intercepts and slopes of the linear relations between the SI and MI with a third variable. This is true, of course, but these differences in the linear relations do not provide any relevant information against or in favour of the hypothesis that the corresponding SI/MIs measure the same underlying construct. The different linear associations may be fully explained by differences in the level and scaling of the two measures versus the underlying construct.

As mentioned, for a few of the 33 variables the correlations differed for the SI and the MI measures in all three datasets. The reason why “overtime” correlated better with MI demand in all 3 datasets could be that one item in the workload-MI is about overtime. The better correlation for “responsibility at work” with SI workload could be due to the fact that the SI asks about workload all in all, which probably covers the workload of a manager whereas the workload-MI include demands that a manager might not feel in the same way as non-managers (e.g. working very fast, reaching all the tasks, overtime). The better correlation of “feeling like going to work” with SI control was especially due to the skill discretion part of control (data not shown). This could be explained by the wording of the skill discretion SI, which includes the word “involving”, which is not directly covered by the items in the skill discretion-MI. If one is involved in the job, he or she might be more feeling like going to work. For “job satisfaction” the better correlation with SI control was also especially due to the skill discretion part. The explanation might again be that involving in work is important for job satisfaction.

Study strength and limitations

To our knowledge this is the first study examining the validity of global single items measuring job demands and control. The strengths of the study are the high number of participants, the high response rates and the concurrent results from the three datasets.

The limitations of the study are the following: 1) As mentioned, we cannot compare the SIs with any true values of demand and control, – instead we compared with scales, which we think measure demand and control with more details. The scales we used as "gold standard" differ as mentioned from Karasek's original JCQ, but this might not be a limitation as the COPSOQ is more detailed than the JCQ. 2) The results might not be generalizable. All data come from hospital employees, who represent different occupations and different social classes, but they might not be representative for all kind of occupations. 3) In both questionnaires the MIs were placed in the beginning and the SIs at the end. The different placing might have influenced the answering differently (ref), but we are not able to tell in which direction. 4) Some of the other variables we used to make correlations with both SIs and MIs were measured with single items, which had not been validated. This could be a problem when estimating the size of the correlations, but not when comparing the correlations for respectively SI and MI, as they are compared with the same (the un-validated variable) and in this context, it has no importance if we know exactly what this "same" is.

Single items limitations and strengths

In our study, the SI concerning skill discretion could be criticized for asking several things at a time, and therefore be difficult to answer. Moreover we do not know precisely which facets of one dimension each SI cover and therefore the SIs measuring demand and control can not be used for e.g. concrete change in working environment. However, our global SIs are not thought as measuring exactly the same as the existent scales, but more as an overall measure of overall demands, workload, decision authority and skill discretion. This could also explain why the correlations between SIs and MIs are not *very* high and no correlations are higher than 0.70. When a respondent answers a global single item about overall demands, it is not sure he is thinking of just those facets of demands included in the scale and if he thinks of these facets, then it is not sure he is weighting each facet equal as the scale does. The fact that global single items catch more precisely what a respondent thinks about an overall concept than multi-item scales, is an important argument in the favour of global single items and it could be the reason why some global single items have been used very successfully. The single item measuring self rated health is very used, and it is assumed to be a good

measure of health and a strong and independent predictor of mortality [193;194]. Overall job satisfaction is also often measured by a single item and has been validated as well [187;195;196]. Single items measuring many other constructs are often used, some of those concerning working conditions are about e.g. social support [197], effort/reward [198-200], unfairness [201], job insecurity [202], work ability [203], stressful work [204] and stress [205-208]. We have found one study using single items measuring both job demands and control [197] and three other studies using different single items measuring job demands[209-211]. In all four studies demands and control were used as predictor variables and it is uncertain whether the results could be seen as a validation of the concerned single items. Some "well validated" single items constitute the SF 8 (ref) which is a "short form" of the SF-36. Each of the 8 single items measure one dimension from the SF-36.

Summing up, it seems as single items are being more and more used and perhaps more and more accepted, as it also appeared from an editorial from 2005[183].

Conclusion

The validation methods in this study seem to support the use of single items as an alternative to multi-item scales when a very detailed measure is not needed. This infers shorter questionnaires with the resulting advantages. Practically Karasek's 9 demand items + 9 control items can be replaced by 1 overall demand single item + 2 control single items. Including many other psychosocial dimensions than demand and control this will result in many spared items and a shorter questionnaire.

Validation is an ongoing process and a measurement as the global single items can not be validated in only a few studies. Other studies should be performed in other populations and in prospective studies to evaluate the predictive power of the global single items. And they could possibly be compared with the original JCQ of Karasek or other scales measuring demand and control and a qualitative interview could contribute to the understanding of what single items and scales are in fact measuring.

Table 1 Basic information on the questionnaire surveys of three Danish hospital populations.

	Hospital I	**Hospital II**	**Hospital III**
Year	2000	2002	2002
Participants	2644	1057	1280
Response rate	84%	86%	87%
Proportion of women	84%	75%	77%
Mean age (SD)	44 years (10.0)	43 years (9.3)	43 years (10.0)

Table 2 Spearman correlations between global single items and the corresponding multi-item scales. Cronbach α for the multi-item scales are shown below the title of each scale.

	multi-item scale																				
	Hospital I							Hospital II							Hospital III						
single item	mean*	SD	workload α = 0.68	overall demands α = 0.82	decision authority α = 0.77	skill discretion α = 0.74	control α = 0.78	mean*	SD	workload α = 0.68	overall demands**	decision authority α = 0.77	skill discretion α = 0.74	control α = 0.78	mean*	SD	workload α = 0.68	overall demands**	decision authority α = 0.77	skill discretion α = 0.74	control α = 0.78
workload	4.0	1.00	**0.55**	0.50	-0.05	-0.21	-0.14	3.7	1.01	**0.48**	-	-0.01	-0.21	-0.12	4.1	1.02	**0.53**	-	-0.06	-0.18	-0.14
overall demands	4.1	0.93	0.38	**0.51**	-0.11	-0.34	-0.25	4.1	0.91	0.29	-	-0.05	-0.26	-0.18	4.2	0.91	0.34	-	-0.06	-0.28	-0.18
decision authority	2.7	1.14	0.02	-0.08	**0.57**	0.35	0.57	2.4	0.97	0.05	-	**0.54**	0.38	0.55	2.8	1.11	0.07	-	**0.53**	0.30	0.52
skill discretion	2.7	1.05	-0.11	-0.29	0.34	**0.67**	0.58	2.4	0.91	-0.08	-	0.27	**0.53**	0.47	2.5	0.96	0.03	-	0.29	**0.50**	0.46
control	2.7	0.92	-0.05	-0.21	0.55	0.59	**0.69**	2.4	0.79	-0.02	-	0.48	0.54	**0.62**	2.6	0.86	0.05	-	0.50	0.47	**0.59**

*) The range for the response categories is 1 – 6 for all the single items.
**) In Hospital II and III there are no available data for multi-item scales measuring overall demands.

Table 3 Spearman correlations between the workload / control variables measured both with single items (SI) and with multi-item scales (MI), and 37 other variables in the 3 datasets.

	w o r k l o a d						c o n t r o l					
	Hospital I		Hospital II		Hospital III		Hospital I		Hospital II		Hospital III	
	SI	MI	SI	MI	SI	MI	SI	MI	SI	MI	SI	MI
gender	0.01	0.01	-0.02	-0.08	-0.02	-0.01	-0.01	0.04	-0.11	0.01	0.03	0.07
age	0.02	0.03	0.04	0.03	0.09	0.12	-0.03	-0.03	0.02	0.04	-0.09	-0.12
job seniority	0.05	0.04	0.15	0.09	0.07	0.07	-0.02	-0.03	-0.02	-0.02	-0.05	-0.11
working hours pr week	0.21	0.18	0.20	0.34	0.23	0.27	-0.05	-0.13	-0.12	-0.18	-0.07	-0.17
overtime work	0.12	0.27	0.14	0.27	0.12	0.22	0.01	0.02	0.10	0.11	0.18	0.18
workload scale	-	-	-	-	-	-	-0.05	-0.08	-0.02	0.01	0.05	-0.04
overall demands scale	-	-	-	-	-	-	-0.21	-0.27	-	-	-	-
decision authority scale	-0.05	0.01	-0.01	0.12	-0.06	0.03	-	-	-	-	-	-
skill discretion scale	-0.21	-0.18	-0.21	-0.12	-0.18	-0.11	-	-	-	-	-	-
meaning of work scale	-0.21	-0.10	-0.15	-0.04	-0.16	-0.08	0.44	0.46	0.48	0.52	0.39	0.48
commitment to work scale	-0.06	-0.03	-0.07	0.02	-0.08	0.01	0.45	0.45	0.48	0.53	0.43	0.45
predictability scale	0.08	0.13	0.02	0.13	0.02	0.16	0.41	0.39	0.38	0.43	0.37	0.37
sense of community scale	0.02	0.09	0.03	0.09	0.05	0.14	0.26	0.23	0.34	0.37	0.27	0.32
role-clarity scale	-0.04	0.10	-0.03	0.08	-0.04	0.06	0.35	0.36	0.39	0.48	0.27	0.37
violence scale	0.08	0.10	0.06	0.12	0.05	0.05	0.00	-0.02	0.16	0.22	0.08	0.08
workload	-	-	-	-	-	-	0.16	0.14	0.16	0.12	0.09	0.14
sufficient time + resources	0.47	0.50	0.46	0.47	0.49	0.47	0.16	0.10	0.20	0.14	0.24	0.12
responsibility at work	-0.35	-0.22	-0.33	-0.12	-0.36	-0.18	0.40	0.36	0.47	0.35	0.37	0.26
overall demands	-	-	-	-	-	-	0.27	0.25	0.31	0.18	0.20	0.18
decision authority	-0.12	0.02	-0.09	0.05	-0.04	0.07	-	-	-	-	-	-
skill discretion	-0.17	-0.11	-0.16	-0.08	-0.10	0.03	-	-	-	-	-	-
psychological work climate	0.06	0.12	0.07	0.10	0.08	0.14	0.37	0.30	0.44	0.32	0.39	0.22
feel like going to work	-0.02	0.06	-0.04	0.11	0.00	0.10	0.47	0.39	0.54	0.38	0.50	0.31
stressful work	-0.38	-0.42	-0.37	-0.37	-0.41	-0.40	-0.17	-0.13	-0.23	-0.15	-0.20	-0.09
job satisfaction	0.03	0.13	0.01	0.12	0.10	0.18	0.55	0.44	0.65	0.45	0.58	0.36
support family / friends	0.03	0.09	0.06	0.08	0.11	0.14	0.14	0.13	0.22	0.14	0.19	0.12
personality, worried	-0.01	0.06	0.03	0.10	0.06	0.09	0.13	0.13	0.18	0.12	0.16	0.17
personality, type A	0.12	0.10	0.19	0.19	0.14	0.13	-0.10	-0.12	-0.05	-0.02	-0.12	-0.11
personality, self efficacy	0.14	0.03	0.13	0.06	0.08	0.02	-0.26	-0.23	-0.25	-0.23	-0.23	-0.23
self rated health	0.00	0.06	0.12	0.12	0.05	0.07	0.22	0.18	0.23	0.16	0.16	0.16
mental health scale	-0.10	-0.21	-0.15	-0.23	-0.20	-0.23	-0.28	-0.24	-0.27	-0.20	-0.27	-0.19
vitality scale	-0.12	-0.22	-0.17	-0.24	-0.20	-0.24	-0.33	-0.27	-0.29	-0.24	-0.30	-0.21
sickness absence	-0.01	0.00	0.03	0.05	-0.09	-0.05	0.14	0.13	0.12	0.09	0.21	0.16
sickness spells	0.00	0.01	0.01	0.03	-0.10	-0.04	0.15	0.12	0.12	0.09	0.20	0.17
sickness presence	0.17	0.16	0.19	0.20	0.15	0.16	0.14	0.08	0.08	0.03	0.04	0.04
low back pain	0.05	0.05	0.08	0.11	0.02	0.06	0.13	0.13	0.11	0.07	0.11	0.05
sick. absence low back pain	0.01	0.03	0.01	0.01	0.00	0.00	0.10	0.07	0.11	0.05	0.10	0.06

Table 4 Parameters for the regression lines of the relationship between SI- and MI-correlations.

	Hospital	α	β	adj R^2
workload	I	-0.03	0.89	0.83
	II	0.04	0.89	0.80
	III	0.05	0.97	0.88
overall demands	I	-0.03	0.82	0.84
decision authority	I	0.01	1.08	0.96
	II	0.01	1.00	0.82
	III	0.01	0.94	0.86
skill discretion	I	0.02	1.00	0.94
	II	0.02	1.02	0.86
	III	0.04	1.03	0.78
control	I	0.01	1.06	0.97
	II	0.00	1.09	0.91
	III	0.02	1.04	0.86
strain	I	0.01	0.83	0.94
	II	0.01	0.97	0.91
	III	-0.02	1.02	0.90

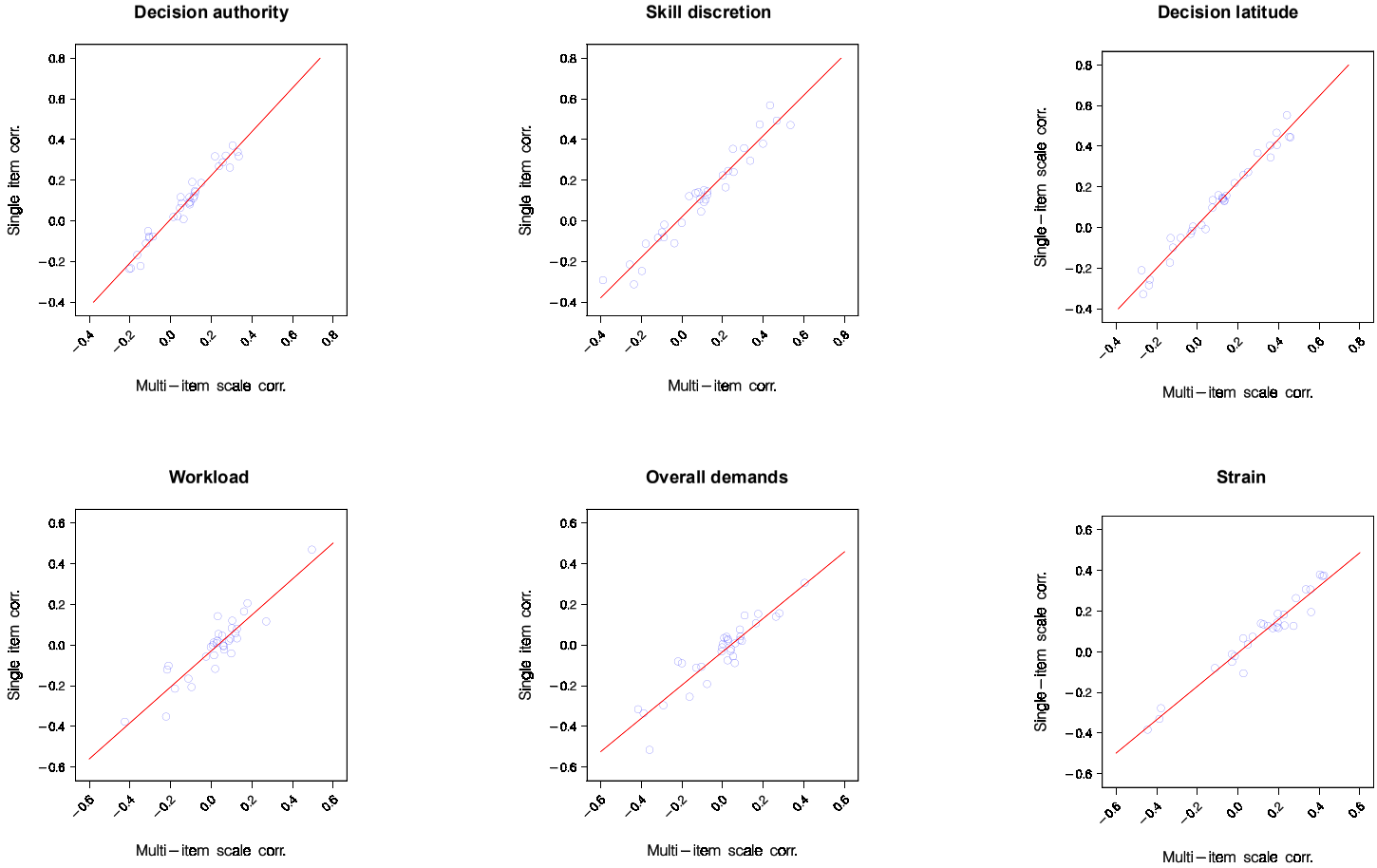


Figure 1
Graphs showing the relationship between correlations in Hospital I.
The correlations between the dimension (e.g. workload) measured by the multi-item scale and 35 other variables on the x-axis. The correlations between the dimension (e.g. workload) measured by the single item and the 35 other variables on the y-axis. The parameters of the regression lines are shown in table 4.

APPENDIX

Overall demand scale

Quantitative demands (workload)

Do you have to work very fast? *

Is your workload unevenly distributed so it piles up? *

How often do you not have time to complete all your work tasks? *

Do you have to do overtime? *

Cognitive demands

Do you have to keep your eyes on a lot of things while you work? *

Does your work require that you remember a lot of things? *

Does your work demand that you are good at coming up with new ideas? *

Does your work require you to make difficult decisions? *

Emotional demands

Does your work put you in emotionally disturbing situations? *

Is your work emotionally demanding? **

Do you get emotionally involved in your work? **

Control scales

Decision authority (In COPSOQ labelled "Influence at work")

Do you have a large degree of influence concerning your work? *

Do you have a say in choosing who you work with? *

Can you influence the amount of work assigned to you? *

Do you have any influence on how you do your work? *

Do you have any influence on what you do at work? *

Skill discretion (In COPSOQ labelled "Possibilities for development")

Is your work varied? *

Does your work require you to take the initiative? **

Do you have the possibility of learning new things through your work? **

Can you use your skills or expertise in your work? **

Response categories:

* always, often, sometimes, seldom, never/hardly ever

** to a very large extent, to a large extent, somewhat, to a small extent, to a very small extent

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Socioeconomic status and duration and pattern of sickness absence. A 1-year follow-up study of 2331 hospital employees.

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Background: Sickness absence increases with lower socioeconomic status. However, it is not well known how this relation depends on specific aspects of sickness absence or the degree to which socioeconomic differences in sickness absence may be explained by other factors.

The purpose of the study was to examine differences in sickness absence among occupational groups in a large general hospital; how they depend on combinations of frequency and duration of sickness absence spells; and if they could be explained by self-reported general health, personal factors and work factors.

Methods: The design is a 1-year prospective cohort study of 2331 hospital employees. Baseline information include job title, work unit, perceived general health, work factors and personal factors recorded from hospital administrative files or by questionnaire (response rate 84%). Sickness absence during follow-up was divided into short (1-3 days), medium (4-14 days) and long (>14 days) spells, and into no absence, "normal" absence (1-3 absences of certain durations) and "abnormal" absence (any other absence than "normal"). Socioeconomic status was assessed by job titles grouped in six occupational groups by level of education (from doctors to cleaners /porters). Effects of occupational group on sickness absence were adjusted for significant effects of age, gender, general health, personal factors and work factors. We used Poisson or logistic regression analysis to estimate the effects of model covariates (rate ratios (RR) or odds ratios (OR)) and their 95% confidence intervals (CI).

Results: With a few exceptions, sickness absence increased with decreasing socioeconomic status. However, the social gradient was quite different for .different types of sickness absence. The gradient was strong for medium spells and "abnormal" absence, and weak for all spells, short spells, long spells and "normal" absence. For cleaners compared to doctors the adjusted risk estimates increased 4.2 (95%CI 2.8-6.2) and 7.4 (95%CI 3.3-16) times for medium spells and "abnormal" absence, respectively, while the similar changes varied from 0.79 to 2.8 for the other absence outcomes. General health explained some of the social gradient. Work factors and personal factors did not.

Conclusions: The social gradient in sickness absence was different for absences of different duration and patterns. It was strongest for absences of medium length and "abnormal" absence. The social gradient was not explained by other factors.

BACKGROUND

Several studies show that sickness absence increases with decreasing socioeconomic status [1-18]. Most studies use a single sickness absence modality as outcome, e.g. number of absence days, any absence spell, or absence spells of a certain duration [5,8,11-17]. However, sickness absence is a complex phenomenon and it's causes vary with frequency and duration of absence spells [4,19]. The impact of socioeconomic status on different aspects of sickness absence could also vary due to socioeconomic differences in work conditions, cultural background, personal factors and health. Only a few studies have examined this problem and most of them consider only a dichotomy of short and long spells [1,3,4,6,7]. We found only two studies that report associations between socioeconomic status and incidence of sickness absence spells divided into more than two duration categories [2,10]. Only a minority have no sickness absence during a calendar year, but they always serve as the "normal" reference group. However, a few absences per year is quite normal and could be independent of work factors, personal factors, socioeconomic status or other explaining factors, e.g. a flue or a broken leg. The "pattern" of different combinations of frequency and duration of absence spells and "normal" versus "abnormal" sickness absence would seem to be a natural field of sickness absence research, including effects of socioeconomic status and other factors. However, we found no studies dealing with these aspects of sickness absence.

Socioeconomic differences in sickness absence are of special interest if they can be explained. Health and working conditions vary with socioeconomic status [20,21] and predict sickness absence [22-24], and could therefore explain some of the socioeconomic differences in sickness absence. This was the case in several studies, although to a varying degree [1,5,8,10,17,18]. Just as socioeconomic effects on sickness absence may differ by different absence modalities (e.g. duration or frequency) the effects of other risk factors like health and working conditions could also vary with such differences.

In the present 1-year follow-up study of employees in a large general hospital we examined the relation between socioeconomic status and objectively recorded sickness absence divided into lengths of 1-3 days, 4-14 days and more than 14 days. Data were analysed as incidence rates and for those with any absence as odds of long versus short absences. We further studied the incidence of a specific sickness absence pattern labelled as "normal" and "abnormal". In the analyses, we adjusted for a large number of potential confounders or mediators to examine if they could explain the effects of socioeconomic status on sickness absence.

METHODS

The study population consisted of all employees at a general hospital in the county of Copenhagen, including somatic and psychiatric departments and supporting staff. Heads of departments were excluded for reasons of confidentiality because information on department and job title would reveal their identity. A baseline questionnaire about working conditions, health and personal circumstances was distributed to 3199 employees by departments and work units at the end of October 2000 followed by two reminders. 2687 (84%) questionnaires were returned before January 2001. By January 1st 2001, 148 employees had stopped working at the hospital and 123 did not work in the same work unit as when they answered the questionnaire. Thirteen had invalid employment data and 14 had invalid data on sickness absence. They were all excluded together with a small group of 58 employees, mainly workmen, with job titles that did not fit into our occupational groups, see below. The material consists of the remaining 2331 questionnaire responders. The participants worked in 28 departments divided into a total of 182 work units, comprising from 1 to 53 persons, the median being 11 persons. The work units were the lowest organisational level of the hospital, typically a ward or ambulatory.

The study was performed in the context of a political quest to improve working conditions and reduce sickness absence, and the purpose of the study was to supply the hospital and the departments with aggregated systematic information about perceived work conditions, health and sickness absence data. The study was supported by management and employee representatives. Participation was voluntary and only research staff had access to person-related data. This was all explained in information leaflets and in an introductory letter with the questionnaire.

The study was reported to The Danish Data Protection Agency. According to Danish law, research projects based only on questionnaires do not need permission from an ethics committee.

Sickness Absence

Participants were followed through hospital administrative data files from January 1st 2001 until the last date employed in the same working unit or to the end of 2001 whichever came first. Data on absences due to ordinary sickness absence was recorded by frequency and duration categories, including number of sickness absence days within each category. Pregnancy related sickness absence was excluded since we assumed it could have other risk factors than ordinary sickness absence. The records did not contain information on diagnoses. Part time sickness absence was used very seldom and such data were not available in this study.

Days at risk for starting a new spell of sickness absence was calculated as calendar days in the follow-up period , excluding Saturdays, Sundays and other holidays, days on vacation, and days of absence due to ordinary sickness, maternity leave, pregnancy related sickness or care of sick child. One day for each sickness absence spell was added since the first day of an absence spell starts as a day at risk.

We defined short spells of sick leave as 1-3 days, medium spells as 4-14 days and long spells as more than 14 days, based on administratively defined cut points in the aggregated absence data we had access to. The incidence rate was defined as all new sickness absence spells during the follow-up period divided by the risk time in the same period. We further grouped the respondents into two groups, one with a "normal" and the other with an "abnormal" absence pattern. Among persons with any absences, "normal" absence was defined as having no more than two short, one medium and one long spell, and altogether no more than three spells of any length during the observation period. Any other combination of absences was considered as "abnormal" absence. These pattern definitions are discussed below.

In Denmark a medical certificate is not mandatory for sickness absence spells but the employer may require one for absences >3 days. Employees can obtain compensation for up to one year of sickness absence. Mostly, and especially in higher occupational grades, the compensation is equal to the normal salary.

Occupational group and socioeconomic status

Based on job titles from the hospital register, education and similarity of work content, we divided the hospital personnel into the following 6 occupational groups: 1) doctors, dentists, psychologists and other academic staff, 2) physiotherapists, midwives, medical laboratory technologists, social workers and alike, 3) nurses, 4) medical secretaries, office, and administrative workers, 5) nursing assistants, 6) cleaning personal, hospital porters, and various assistants. In the text we will refer to this ordered occupational grouping as a measure of graded socioeconomic status, although we acknowledge that there is no clear socioeconomic status difference between groups 2) and 3).

Demographic and personal variables

Age and gender were registered in the hospital records. Information on cohabitation and children at home was gathered by questionnaire. Social support from family or friends was measured by a single item (If you have problems, can you obtain the help and support you need from your family and friends? (always, almost always, usually, often, now and again, rarely/ never)) Personality characteristics was measured by three single items, covering negative affectivity (Do you as a person have a tendency to worry, or be nervous or a little pessimistic? (not at all, slightly, a little, some, quite a lot, fairly much, very much)), type A behaviour (Do you as a person have a tendency to be competitive, proud, ambitious and a little impatient? (same response alternatives)), and self efficacy (Are you the kind of person who can almost always solve difficult problems, cope with unforeseen situations and achieve your goals? (not at all, slightly, a little, some, quite a lot, fairly much, very much)). General health was measured by a single item from SF36 [25].

Work time and schedule variables

Regular working hours per week, frequency of duties on evenings/nights, frequency of weekend

duties, and overtime work was recorded by questionnaire.

Work related psychosocial variables

Work related quantitative demands (4 items), cognitive demands (4 items) and emotional demands (3 items), decision authority (5 items) and skill discretion (4 items), support from colleagues and superiors at work (4 items), meaning of work (2 items), commitment to the workplace (4 items), predictability (2 items), sense of community (3 items), role-clarity (4 items), quality of leadership (5 items), and role-conflicts (1 item) were measured with scales and items from the first edition of the Copenhagen Psychosocial Questionnaire, COPSOQ [26]. An overall job demand scale was constructed by taking the mean of the 3 demand scales, and a control scale was constructed as the mean of the decision authority and skill discretion scales. Threats and violence was measured with a 3 item scale (Have you, within the last 12 months, during work been exposed to 1) verbal or written menaces? 2) menacing behaviour? 3) pushes, beating, kicks, bites? (response categories: no, yes once, yes 2-5 times, yes, 5-10 times, yes, >10 times)). We further used single items to measure overall job satisfaction (How satisfied are you with your work, all in all?, very satisfied, quite satisfied, satisfied, slightly dissatisfied, quite dissatisfied , very dissatisfied)), feeling like going to work (How much do you normally feel like going to work? (very much, reasonably much, to some extent, slightly reluctant, very reluctant, extremely reluctant)), feeling unsafe at work (Do you ever feel unsafe at work? (always, often, sometimes, never)), and a measure of available time and resources which we interpret as a proxy of the effort required to perform the work tasks (Do you have sufficient time and resources to perform your tasks satisfactorily? (to a very great extent, to a great extent, to some extent, to a lesser extent, to a very little extent, hardly at all)), and reward (Do you feel your work efforts are sufficiently appreciated? (same response categories)). The proxy effort and reward items were included in the analyses by the ratio effort/reward [27]). In this set of variables we also included a single item to assess the overall degree of physical work demands (Is your work physically demanding? (to a very high degree, to a high degree, somewhat, to a low degree, to a very low degree))

Statistical analysis

The association between occupational group and number of incident sickness absence spells was examined in Poisson regression models allowing for overdispersion and with the logarithm of days at risk as offset. Rate ratios (RR) and their 95% confidence intervals (CI) for occupational groups with the group of doctors as reference were calculated for short, medium, long and any sickness absence spells. The associations between occupational group and "normal" and "abnormal" absence versus no absences were examined in logistic regression analyses with days at risk included as a covariate.

Among participants with absence spells we further examined the odds of a longer compared to a shorter sickness absence period. We defined three mutually exclusive groups of participants with sickness absence: 1) participants who had only had short absences, 2) participants with any medium but no long absences, and 3) participants with any long absences. In three separate analyses we examined the odds of belonging to one of these groups versus belonging to one of the others, excluding the third group The binary outcome was scored 1 for the longer and 0 for the shorter absence.

Odds ratios (OR) and their 95%CI for occupational groups with the group of doctors as reference were calculated.

Persons working in the same units might have unknown factors in common, factors that made them choose to work in the unit and factors due to influences from working in the unit. We included a random work unit effect in all regression analyses to adjust for these contextual similarities within work units [28].

The analyses were carried out stepwise, starting with an "empty" model including only the random work unit effect. Subsequent models all included occupational group, gender and age as explaining variables in addition to the work unit random effect. When analysing the incident number of short, medium and long absences, the presence (yes/no) of any other length of absence was also included among these covariates to control for the overlap between spells of different lengths. Groups of covariates were then introduced separately to see

whether the covariates in the group could explain occupational group differences in sickness absence. The groups of covariates were: 1) work related psychosocial variables, 2) work time and schedule variables 3) personal variables and 4) general health. The factors included as covariates were considered to be potential risk factors for sickness absence [19] and could therefore act as mediators or confounders of the relation between socioeconomic status and sickness absence. A fully adjusted model including all covariates was reduced by backward elimination of non-significant ($p>0.05$) covariates from these four groups, successively eliminating the least significant covariate ($p>0.05$). The resulting models were controlled by re-introducing each of the eliminated covariates, one by one, and if significant ($p\leq0.05$), the covariate was retained in the model. We examined for interactions between occupational group and gender in all models. Analyses were made with PROC GLIMMIX, SAS (9.1).

RESULTS

The mean age of the study population was 44 years; nurses were on average the youngest occupational group. Eighty-four percent of the study population were women. Gender was unequally distributed in the occupational groups; the groups of nurses, medical secretaries and physiotherapists consisted of nearly only women and except for the doctors group the other groups consisted mostly of women. Five percent reported poor general health, from 3% of the doctors to 10% among the cleaners/porters group. (Table 1.) Among the 2331 participants,

Table 1 Distribution of sickness absence spells and occupational groups by age, gender and self-reported general health.

	Total	Age	Women	Fair or poor general health
		mean (SD)	n (%)[1]	n (%)[1]
Sickness absence				
No absence	442	44 (11)	344 (78)	15 (3.4)
Any absence	1889	43 (10)	1610 (85)	106 (5.6)
Any short spells (1-3 days)	1693	43 (10)	1443 (85)	97 (5.7)
Any medium spells (4-14 days)	1034	43 (10)	884 (85)	69 (6.7)
Any long spells (>14 days)	209	45 (10)	190 (91)	24 (12)
"Normal" absence pattern[2]	970	45 (10)	814 (84)	38 (3.9)
"Abnormal" absence pattern[3]	919	42 (10)	796 (87)	68 (7.4)
Occupational group				
Doctors[4]	258	45 (10)	109 (42)	7 (2.7)
Physiotherapists[5]	294	45 (10)	281 (96)	24 (8.2)
Nurses	710	41 (10)	681 (96)	20 (2.8)
Medical secretaries[6]	328	45 (11)	311 (95)	21 (6.4)
Nursing assistants	491	45 (10)	424 (86)	25 (5.1)
Cleaners /porters[7]	250	44 (11)	148 (59)	24 (9.6)

Table 1
1) Percent of total
2) Any absence, but no more than two short, one medium and one long spell, and altogether no more than three spells of any length
3) More than either two short spells, one medium spell or one long spell, or more than three spells of any length
4) Doctors, dentists, psychologists and other academic staff
5) Physiotherapists, midwives, medical laboratory technologists, social workers and alike
6) Medical secretaries, office, IT and administrative workers
7) Cleaning personal, hospital porters, and various assistants

1889 (81%) had at least one sickness absence spell during the follow-up year. Figure 1 shows the distribution of short, medium and long absence spells. It appears that there were large overlaps.

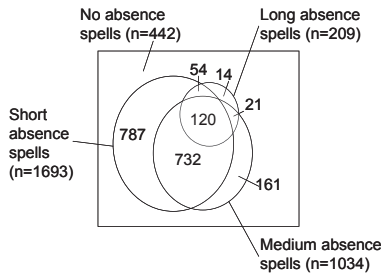
Table 2 shows the sickness absence characteristics in the total sample. Women had more of all types of absences than men. The group of 50-69 years-old had fewer absences of short and medium duration than the other age groups. "Normal" absence increased with age and "abnormal" absence decreased with age. Persons reporting fair or poor health had more of all types of absences, except "normal" absence, than people reporting good or excellent health.

Fewer in the groups of doctors and physiotherapists had absences (62% and 73%, respectively), than in the other groups (82-89%). Nursing assistants had the highest median number of absence spells, the highest frequencies of short and long spells and of "abnormal" absence, but the lowest of "normal" absence. In contrast, the group of doctors had the lowest median number of absence spells, the fewest absences of short, medium and long duration and the lowest frequency of "abnormal" absence. The cleaners/porters group had much more absence of medium duration (64%) than the other groups.

Table 3 shows results from the final reduced models with adjusted RRs for the incidence of absence spells with the group of doctors as reference. For medium spells, a socioeconomic gradient was obvious with the highest RR being 4.19 (95%CI 2.84-6.19) for the cleaners/porters. For the other outcomes the overall pattern was rather similar except that the RR for the group of cleaners/porters dropped below that of nursing assistants, and for short spells even below that of all other occupational groups. There was also a clear and steep socioeconomic gradient for "abnormal" absence with an OR=10.5 (95%CI 5.30-20.8) for nursing assistants compared to the group of doctors. The differences were less pronounced for all spells, short spells and "normal" absence. For long spells there were no significant differences between the occupational groups or between any of these and the group of doctors. The confidence intervals were rather wide reflecting that relatively few cases had long spells of sickness absence.

Table 3 also shows the RR or OR estimates from start models with adjustment for only gender, age, work unit, and effects of other absence spells or

Figure 1 Distribution of sickness absence spells of different durations.
Short = 1-3 days, medium = 4-14 days, long ≥ 15 days.



days at risk (see section on statistical analyses and footnotes to Table 3), and the mean percentage change of these estimates from the start model to the final model. If the effects of socioeconomic differences were mediated through the covariates in the final model one would expect that risk estimates would change in the direction of unity and that socioeconomic differences in the start model would be reduced [1,14]. However, the risk estimates changed very little. The largest reduction was for long absence spells with an 11% mean reduction of occupational group estimates but the opposite was found for "normal" and "abnormal" absence with a mean increase of 15% and 17%, respectively. The introduction of general health into the models reduced most risk estimates, especially for long absence spells and for "abnormal" absence, especially for the group of cleaners/porters (16% and 17% for the two outcomes, respectively, data not shown). The introduction of work-related psychosocial variables did not reduce the differences in risk-estimates between the occupational groups. On the contrary, they tended to increase the differences, especially for medium and long spells and for "abnormal" absence (data not shown).

Table 4 shows the associations between occupational group and distribution of absence spell durations among participants with any absence. Nursing assistants had the highest proportion of absences of long duration. The doctors group had more absences of short duration and less of medium

Table 2 Sickness absence characteristics among the total sample. By age, gender, general health and occupational group.

	Total	Any absence	Any short spells (1-3 days)	Any medium spells (4-14 days)	Any long spells (>14 days)	"Normal" absence pattern[1]	"Abnormal" absence pattern[1]	Days at risk of a new absence spell[2]	Number of absence spells per person-year at risk	Number of absence days in percent of all working days[2] Group total
	N	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	mean (SD)	median	%
Age										
18-29	235	191 (81)	175 (74)	106 (45)	22 (9)	76 (32)	115 (49)	173 (64)	4.00	7.3
30-39	628	512 (82)	469 (75)	299 (48)	41 (7)	246 (39)	266 (42)	182 (62)	3.14	5.6
40-49	715	596 (83)	527 (73)	318 (44)	69 (10)	306 (43)	290 (41)	193 (55)	3.07	6.3
50-69	753	590 (78)	522 (69)	311 (41)	77 (10)	342 (45)	248 (33)	200 (47)	2.05	6.0
Gender										
Women	1954	1610 (82)	1443 (74)	884 (45)	190 (10)	814 (42)	796 (41)	190 (55)	3.07	6.4
Men	377	279 (74)	250 (66)	150 (40)	19 (5)	156 (41)	123 (33)	189 (61)	2.06	4.7
General health										
Fair or poor	121	106 (88)	97 (80)	69 (57)	24 (10)	38 (31)	68 (56)	178 (64)	5.11	11.3
Good, very good or excellent	2177	1757 (81)	1573 (72)	949 (44)	178 (8)	920 (42)	836 (38)	191 (55)	3.03	5.8
Occupational group[1]										
Doctors	258	159 (62)	149 (58)	40 (16)	9 (3)	119 (46)	40 (16)	168 (71)	1.06	2.4
Physiotherapists	294	216 (73)	207 (70)	90 (31)	21 (7)	117 (49)	99 (34)	198 (52)	2.06	4.7
Nurses	710	594 (84)	538 (76)	305 (43)	62 (9)	310 (44)	284 (40)	191 (55)	3.07	5.7
Medical secretaries	328	269 (82)	248 (76)	149 (45)	23 (7)	137 (42)	132 (40)	191 (56)	3.01	5.4
Nursing assistants	491	437 (89)	386 (79)	290 (59)	71 (14)	190 (39)	247 (50)	191 (52)	4.05	9.0
Cleaners/porters	250	214 (86)	165 (66)	160 (64)	23 (9)	97 (39)	117 (47)	197 (50)	3.05	7.2
Total	2331	1889 (81)	1693 (73)	1034 (44)	209 (9)	970 (42)	919 (39)	190 (56)	3.04	6.1

1) See table 1 2) Maximum 227 working days in one year.

Table 3 Effects of occupational group on number and patterns of sickness absence spells. Results from multiple Poisson regression analyses (rate ratios (RR) and their 95% confidence intervals (CI)) of all spells, short, medium and long spells, and from multiple logistic regression analysis (odds ratios (OR) and their 95%CI) of "normal" and "abnormal" absence patterns versus no absence spells.

	All spells[1]		Short spells (1-3 days)[2]		Medium spells (4-14days)[3]		Long spells (>14 days)[4]		"Normal" absence pattern versus no absence[5]		"Abnormal" absence pattern versus no absence[6]	
	Start model	Final model	Start model	Final model	Start model	Final model	Start model	Final model	Start model	Final model	Start model	Final model
Occupational group[7]	RR	RR (95% CI)	RR	RR (95% CI)	RR	RR (95% CI)	RR	RR (95% CI)	OR	OR (95% CI)	OR	OR (95% CI)
Doctors	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Physiotherapists	1.45	1.43 (1.13-1.83)	1.39	1.36 (1.06-1.74)	1.56	1.52 (1.00-2.32)	1.19	1.03 (0.33-3.21)	1.19	1.29 (0.70-2.37)	2.13	2.27 (1.07-4.83)
Nurses	1.58	1.68 (1.36-2.08)	1.35	1.46 (1.18-1.82)	2.20	2.29 (1.59-3.30)	1.49	1.41 (0.50-3.95)	1.98	2.35 (1.39-3.97)	4.42	5.54 (2.87-10.7)
Medical secretaries	1.64	1.72 (1.37-2.16)	1.34	1.43 (1.14-1.81)	2.65	2.81 (1.92-4.13)	1.10	1.06 (0.35-3.24)	1.71	2.03 (1.12-3.67)	4.83	6.31 (3.06-13.0)
Nursing assistants	1.99	1.95 (1.58-2.41)	1.43	1.47 (1.18-1.82)	3.41	3.34 (2.33-4.80)	2.33	1.89 (0.68-5.28)	2.54	2.90 (1.65-5.09)	9.52	10.5 (5.30-20.8)
Cleaners/ porters	1.52	1.41 (1.10-1.80)	0.83	0.79 (0.60-1.03)	4.30	4.19 (2.84-6.19)	1.63	1.37 (0.45-4.13)	2.09	2.43 (1.25-4.70)	6.60	7.39 (3.33-16.4)
p[8]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.10	0.13	0.006	0.001	<0.0001	<0.0001
Mean change of estimates compared to start model		0 %		2.2 %		0.6 %		-11 %		15 %		17%

1) Start model adjusted for age, gender, work-place unit. Final model as start model and for violence, job satisfaction, weekly work hours, being single and general health.
2) Start model adjusted for age, gender, work-place unit, any medium absence, any long absence. Final model as start model and for quality of leadership, social support at work, job satisfaction, weekly work hours, being single and general health.
3) Start model adjusted for age, gender, work-place unit, any short absence, any long absence. Final model as start model and for overall demands, control, job strain, job satisfaction, being single and general health.
4) Start model adjusted for age, gender, work-place unit, any short absence, any medium absence. Final model as start model and for violence and general health.
5) Start model adjusted for age, gender, work-place unit, days at risk. Final model as start model and for overall demands, control, job strain, weekly work hours, overtime work and general health.
6) Start model adjusted for age, gender, work-place unit, days at risk. Final model as start model and for overall demands, control, job strain, weekly work hours and general health.
7) See table 1. 8) Probability of no difference between occupational groups, χ^2-test.

Table 4 Sickness absence characteristics of persons with any sickness absence (n=1889). By occupational group. Odds ratios (OR) with 95% confidence intervals (CI) of medium versus short, long versus short and long versus medium spells, adjusted for other significant covariates in multiple logistic regression analysis (see text).

			Longest absence spell[1]			Results from logistic regression analyses, final model		
Occupational group[5]	Number of persons with any absence n	Number of absence days per year median	Short (1-3 days) n (%)	Medium (4 -14 days) n (%)	Long (>14 days) n (%)	Medium versus short spells[2] OR (95% CI)	Long versus short spells[3] OR (95% CI)	Long versus medium spells[4] OR (95% CI)
Doctors	159	3	116 (73)	34 (21)	9 (6)	1.00	1.00	1.00
Physiotherapists	216	7	117 (54)	78 (36)	21 (10)	2.24 (1.25-4.03)	1.51 (0.58-3.96)	0.95 (0.32-2.79)
Nurses	594	8	265 (45)	267 (45)	62 (10)	3.24 (1.94-5.40)	2.27 (0.98-5.29)	0.78 (0.29-2.07)
Medical secretaries	269	8	111 (41)	135 (50)	23 (9)	4.49 (2.60-7.78)	2.09 (0.83-5.26)	0.58 (0.20-1.67)
Nursing assistants	437	11	131 (30)	235 (54)	71 (16)	5.84 (3.41-9.99)	4.25 (1.83-9.87)	0.84 (0.31-2.27)
Cleaners/porters	214	12	47 (22)	144 (67)	23 (11)	11.2 (6.08-20.8)	4.71 (1.82-2.19)	0.72 (0.25-2.07)
Total	1889	9	787 (42)	893 (47)	209 (11)			
p[6]						<0.0001	0.0003	0.8151
Mean change of estimates compared to start model						6.2 %	-11.0 %	3.4 %

1) Short = only short spells. Medium = any medium but no long spells. Long = any long spells. See figure 1.
2) Adjusted for age, gender, work-place unit, follow-up time, overall demands, control, job strain and general health. Persons with long spells (n=209) were excluded from the analyses.
3) Adjusted for age, gender, work-place unit, follow-up time, violence and general health. Persons with medium spells (n=893) were excluded from the analyses
4) Adjusted for age, gender, work-place unit, follow-up time, violence, insecurity at work, duties and general health. Persons with short spells (n=787) were excluded from the analyses.
5) See table 1.
6) Probability of no difference between occupational groups, χ^2-test.

and long duration than the other groups. Remarkably, among cleaners and porters with any absence, only 22% had only had short spells and 67% had at least had a spell of medium length. For the doctors group the corresponding figures were 73% and 21%.

For medium versus short spells the ORs increased markedly with decreasing socioeconomic status. The OR for cleaners/porters was 11.2 (95%CI 6.08-20.8) compared to the group of doctors. The pattern was similar but less marked for long versus short spells. The OR for cleaners/porters was 4.71 (1.82-2.19) compared to the group of doctors. There were no significant effects of occupational group on long versus medium spells.

Occupational group differences did not change much from a basic model with adjustment for only age, gender, work unit and days at risk to the final model (data not shown). Adjustment for other significant covariates reduced the occupational group OR's by an average of 11% for long versus short spells, and increased slightly for the other comparisons. The effects of introducing general health and work related psychosocial factors into the models followed the same pattern as for the risk estimates of incident absence spells (data not shown).

The proportion of variance explained by random work unit effects was small, approximately 2-7% in all models with individual level covariates (data not shown).

DISCUSSION

For most of our measures of sickness absence the results showed clear differences between the occupational groups. The group of doctors had fewer absence spells and they were of shorter duration than for the other groups, and the groups of cleaners/porters and nursing assistants had more absence spells and spells of longer duration. The remaining groups were in between.

Our ordering of the occupational groups reflects their socioeconomic status by educational level, positions within the hospital hierarchy and level of wages, except that the group of nurses and the group of physiotherapists should be ranked equal. We did not collapse these two groups because the size of each of them was sufficient to be considered separately in the analyses. The occupational group classification and ordering was based on common knowledge, not on specific personal data except job title.

A socioeconomic gradient was obvious for the incidence of medium spells, "abnormal" absence (table 3), and for the odds of spells of medium and long duration versus spells of short duration (table 4). The incidence of long sickness absence spells was not significantly different for the occupational groups. For the incidence of short spells there was a significant difference between the occupational groups but no obvious socioeconomic gradient. Actually, the lowest socioeconomic group, cleaners and porters, had a lower risk of short spells than the highest socioeconomic group of doctors (table 3). The lack of a socioeconomic gradient in absence spells of 1-3 days may be explained by the increasing proportion of medium versus short spells with decreasing socioeconomic status (table 4). The longer absences in the lower socioeconomic groups could be due to a different pattern of medical causes of sickness absence, to different conditions for returning to work, or to different sickness absence attitudes and behaviours. The lack of a socioeconomic gradient in absence spells of 1-3 days was also found in another study [4]

A socioeconomic gradient in sickness absence is in accordance with results from previous studies [1-8,10-18], but study results are difficult to compare because of different study populations, methods, cultures and legislation, and to different outcome measures Some studies report only results for absence spells of a certain duration, ≥1 day [15], >3 days [12], >7 days [5,8,17], ≥1 week [13], ≥ 14 days [16] and ≥8 weeks [11,14] including persons with none or shorter absence spells in the reference group. Other studies report results for short as well as long absences but with large variations in cut-points, long absences being defined as more than 2 days [6], 3 days [4], 7 days [1,3] and 10 days [7] of absence. The results of our study indicate that the cut points for absences of different duration may have a considerable impact on the results of a study on socioeconomic effects on sickness absence.

Only a few studies mention the problem that the same person may have several absence spells of different durations. This overlap should be taken into account in the analyses by stratification [29] or statistical adjustment [2], as we did in the present study. However, with a substantial overlap between sickness absences of different duration there is a

risk of overadjustment. We therefore reanalysed the final models for short, medium and long absences without adjusting for the effects of other types of absence. The results of these analyses (data not shown) were consistent with the results shown in table 3.

Only a few other studies have examined several different dimensions of sickness absence [30-33]. One study examined sickness absence of '>14 days total', 'mean spell duration >7 days', and '>2 spells of absence' [32]; another studied outcomes defined as '≥3 sick leaves', '> 1 week absence', and '≥1 long spell (>15 days)' [31]. However, these different outcome measures were studied separately. We are not aware of other studies that combined different aspects of sickness absence into a single measure of a distinct absence "pattern". An attractive side of this idea was that it solved the problem of large overlaps between sickness absence spells of different lengths (figure 1). We arbitrarily considered sickness absence as "normal" if a person had no more than two short, one medium and one long absence spell, and no more than three absence spells all together. Any other absence pattern was labelled as "abnormal". By this definition 61% of our population had no absences or a "normal" absence pattern, and 39% had "abnormal" absence. Our first intention was to collapse no absences and "normal" absence to serve as a "normal" reference group to "abnormal" absence. However, as shown in table 2 and 3, even the "normal" absence showed distinct patterns of associations to age, gender, general health and occupational group that were different from those of no absence and "abnormal" absence. Therefore, we report the results for "normal" absence without collapsing this group with the group with no absences. However, our assumptions about a "normal" absence were partly met since the socioeconomic gradient for "normal" absence was much less pronounced than for "abnormal" absence (table 3). There was also an effect of general health on "normal" sickness absence, but much weaker than for "abnormal" absence (data not shown).

We acknowledge that our definition of normal/abnormal sickness absence is based solely on the subjective opinions of the authors. However, our definition was made before analysing the data and we did not explore alternative definitions. Although our a priori assumption that "normal" absence was not associated with socioeconomic status and general health proved to be wrong, we suggest that the approach of defining distinct patterns of sickness absence should be further elaborated using more sophisticated analytical and objective methods in future studies.

We were only able to explain very little of the occupational group differences in sickness absence despite controlling for a large number of potential risk factors, including work time and schedule variables, an extensive set of psychosocial work environment variables, family and personal aspects, and general health. Self-rated general health was a consistent, strong and statistically significant risk factor for all aspects of sickness absence, and was rated poorer with decreasing socioeconomic status (Table 1). These results are in accordance with other studies [5,21,23,34]. However, occupational group differences in sickness absence diminished only a little when general health was controlled for. Thus, in our study, general health only seemed to act as a weak mediator of socioeconomic differences in sickness absence. This is in accordance with some [8,16] but not with other studies [18]. Socioeconomic differences in sickness absence may differ by type of medical disorder[4,10,35]. In Denmark, however, information about medical disorders as causes of sickness absences is neither systematically required nor recorded.

We found only a few significant effects of work related psychosocial factors on sickness absence. Occupational group differences were not explained by these factors. In fact, adjustment for psychosocial factors tended to increase the differences (data not shown). Our results are in accordance with some [14,16] but not with other studies [10,17,18]. In a representative sample of employees in Norway, psychosocial work environment did not explain socioeconomic differences in sickness absence spells of ≥14 days [16]; in a random sample of Danish employees with sickness absence exceeding 8 weeks psychosocial work environment explained very little of socioeconomic differences after adjustment for physical work environment factors [14]. In other studies, psychosocial work environment explained from 24% to 46% of the socioeconomic differences in sickness absence [10,17,18]. Physical working

conditions seemed to be a stronger determinant of sickness absence than psychosocial working conditions [14] and a stronger modifier of socioeconomic effects [14]. However, the size of attributable fractions depends on other factors in the model. A better understanding of the causal pathways leading to sickness absence requires repeated measurements of factors of interest at regular intervals.

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We have limited our study to sickness absence in the work unit where the participants worked when they filled the questionnaire, and we used maximally one year follow-up on sickness absence. We therefore believe that risk factors recorded at baseline have been rather stable during the observation period. Furthermore, incidence rates were strictly based on days at risk of a new absence spell, excluding all sickness absence days, except for the first day, and all days with absences for other reasons. Another strength of our study is the high response rate which makes it unlikely that non-response bias could seriously distort the pattern of effect estimates and interpretation of study results.

Limitations of the study include its generalizability, being a study of a single large hospital. Also, we would have preferred more information on medical and other reasons for absences, and exact dates on sickness absences and days at risk. Lack of information about specific physical word loads and about life style risk factors is also a shortcoming. However, the effect of life style risk factors on sickness absence may be mediated, at least partly, by their effect on general health which we controlled for in the analyses. Finally, several potential confounders were measured by a single item which is less reliable than a multi-item scale measuring the same construct. However, the lower reliability may be compensated by a larger study population [36].

CONCLUSIONS

We found clear differences in sickness absence between the occupational groups. A strong socioeconomic gradient was found for the incidence of medium spells and “abnormal” absence; and for persons with sickness absences the proportion of medium spells increased and the proportion of short spells decreased with decreasing socioeconomic status. Thus, socioeconomic status was differently related to sickness absence of different duration and pattern. We found no clear explanation for the relations between sickness absence and socioeconomic status. Sickness absence increased with poor general health but general health explained very little of the association between sickness absence and socioeconomic status. Work related factors and personal factors had only sporadic significant effects in this study. However, some of these factors were only measured by a single item.

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Job strain, iso-strain and sickness absence - A 1-year prospective study of hospital employees.

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Objectives: To examine if sickness absence is influenced by job stress according to the strain and iso-strain hypotheses of the Karasek demand-control-support (DCS) model.

Methods: The design is a 1-year prospective cohort study of 2331 hospital employees. Baseline data included information about perceived demands, control and support (response rate 84%). Sickness absence during follow-up was divided into short (1-3 days), medium (4-14 days) and long (>14 days) spells, and into no absence, "normal" and "abnormal" absence patterns. The effects of demands, control and support and multiplicative interaction terms for strain and iso-strain were analysed in Poisson and logistic regressions models, adjusting for age, gender, work unit, general health, personal factors and socioeconomic status. The effects of model covariates were calculated as rate ratios or odds ratios and their 95% confidence intervals.

Results: We found a significant interaction between demands, control, and support in the analyses of short spells, and a significant interaction between demands and control in the analyses of medium spells. However, the pattern of effects of combinations of different levels of demands, control and support did not fit with the predictions of the DCS model. There were no other significant interactions or effects of demands, control and support.

Conclusions: Our results did not support the interaction hypotheses of the DSC model. Several other studies have tested these hypotheses with similar results. It is concluded that the job strain and iso-strain hypotheses of the DCS model in relation to sickness absence are not supported by data from observational studies.

Keywords: absenteeism; cohort study; demand control support model; epidemiology; interaction; pattern of absence; sick leave; stress model; stressor; work environment

During the last decades political concerns about sickness absence have increased in many developed countries. The scientific interest in the subject has been growing and a number of scientific studies on causes of sickness absence have been initiated(1). Many of these studies have focused on the role of a poor working environment, especially the role of work related stress(2-6).

The dominant generic model of work related stress is the demand-control-support (DCS) model introduced by Karasek(7-9). The original model claims that high demands at work are harmful to health if they are not accompanied by a high level of control at work. Control at work is also called decision latitude, and is defined as a combination of decision authority and skill discretion. The combination of high demands and low control is termed job strain. Social support at work is included in an extended model stating that strain is

particularly harmful if social support at work is low(8;9). This situation is termed iso-strain.

Many studies examine the separate independent effects of demands, control and support on sickness absence but relatively few studies have examined their combined effects in terms of strain and iso-strain(4;5;10-29). Most of these studies only examined the combined DCS effects as additive effects(4;14-16;18-22;24-28), and not if the presence of one factor modified the effects of the other factors, although such interactions seem to be the distinguishing feature of the model(30;31). Furthermore, even though the DCS variables were measured as continuous variables or with several response categories, most studies examine the effects of strain and iso-strain only after dichotomising the variables, usually at the median score.

Sickness absence of different duration may be differently related to psychosocial factors at work(4;32). However, the effects of the DCS model on sickness absence of different durations are largely unknown.

The purpose of this study was to examine the impact of the DCS stress model on subsequent sickness absence rates, utilising all of the information from the original distributions of the basic constructs of demands, control and support. We examined if the effect of each of these constructs was modified by the level of the other constructs in a manner that was consistent with the model(9). We used a 1-year prospective study design and collected objectively recorded sickness absence data, divided into short (1-3 days), medium (4-14 days) and long (> 14 days) spells of absence, and further defined a combined measure of sickness absence.

METHODS

The study population consisted of all employees at a general hospital in the county of Copenhagen. A baseline questionnaire about working conditions, health and personal circumstances was distributed to 3199 employees by departments and work units at the end of October 2000 followed by two reminders. 2687 (84%) questionnaires were returned before January 2001. By 1 January 2001, 148 employees had stopped working at the hospital and 123 did not work in the same work unit as when they answered the questionnaire. Thirteen had invalid employment data and 14 had invalid data on sickness absence. They were all excluded together with a group of 58 employees, mainly workmen, with job titles that did not fit into our occupational groups, see below. The material consists of the remaining 2331 questionnaire responders. The participants worked in 28 departments divided into a total of 182 work units, comprising from 1 to 53 persons, the median being 11 persons. The work units were the lowest organisational level of the hospital, typically a ward or ambulatory.

The study was performed in the context of a political quest to improve working conditions and reduce sickness absence in Copenhagen County work places. Participation was voluntary and only research staff had access to person-related data.

The study was carried out in accordance with the requirements of the Danish national and regional ethics committees and the Danish Data Protection Agency.

Sickness Absence

Participants were followed through hospital administrative data files from 1 January 2001 until the last date employed in the same working unit or to the end of 2001, whichever came first. Data on absences due to sickness were recorded by frequency and duration categories, including number of sickness absence days within each category. The records did not contain information on diagnoses.

Days at risk for starting a new spell of sickness absence was calculated as calendar days in the follow-up period, excluding Saturdays, Sundays and other holidays, days on vacation, and days of absence due to ordinary sickness, maternity leave, pregnancy related sickness or care of sick child. One day for each sickness absence spell was added since the first day of an absence spell starts as a day at risk.

We defined short spells of sick leave as 1-3 days, medium spells as 4-14 days and long spells as more than 14 days, based on cut points in the aggregated absence data we had access to. The incidence rate was defined as all new sickness absence spells during the follow-up period divided by the risk time in the same period. We further grouped the respondents into two groups, one with a 'normal' and the other with an 'abnormal' absence. An 'abnormal' absence was defined as having *either*

more than two spells of short absence, *or* more than one spell of medium absence, *or* more than one spell of long absence, *or* more than 3 spells of any length during the observation period. All other absence combinations, including no absence, were considered as 'normal'.

In Denmark a medical certificate is not mandatory for sickness absence spells but the employer may require one for absences >3 days. Employees can obtain compensation for up to one year of sickness absence. Mostly, and especially in higher occupational grades, the compensation is equal to the normal salary.

Demand-Control-Support variables

Work related quantitative demands (4 items), cognitive demands (4 items) and emotional demands (3 items), decision authority (5 items), skill discretion (4 items) and social support (5 items) were measured with scales and items from the first edition of the Copenhagen Psychosocial Questionnaire, COPSOQ(33) (see appendix). Each item had 5 verbally anchored response categories. An overall job demand scale was constructed by taking the mean of the 3 demand scales, and a control scale was constructed as the mean of the decision authority and skill discretion scales.

Other work related psychosocial variables

Meaning of work (2 items), commitment to the workplace (4 items), predictability (2 items), sense of community (3 items), role-clarity (4 items), quality of leadership (5 items), and role-conflicts (1 item) were measured with scales and items from the first edition of COPSOQ. Effort and reward were measured by two single items (6 verbally anchored response categories) and an effort-reward imbalance variable, ERI, was constructed by dividing effort by reward(34). Threats and violence was measured with a 3 item scale. Single items were used to measure a feeling of not being safe at work (4 verbally anchored response categories), overall job satisfaction, how you feel like going to work and overall degree of physical work demands (6 verbally anchored response categories).

The response categories for all items were graded and assigned numerical values (1, 2, 3 etc.) with higher values indicating poorer work environment (high demands, low control etc.). All scale values were calculated as the mean of item values. If half or more items in a scale were missing, the scale value was set to missing.

Other variables

Age and gender were registered in the hospital records. Information on cohabitation and children, regular working hours per week, frequency of duties on evenings/nights, frequency of weekend duties, and overtime work was recorded by questionnaire. Social support from family or friends was measured by a single item and personality aspects was measured by three single items, covering negative affectivity, type A behaviour and self efficacy(35;36). General health was measured by a single item from SF36(37).

Based on job titles from the hospital register, education and similarity of work content, we divided the hospital personnel into the following 6 occupational groups as a proxy of socioeconomic status (SES): 1) doctors, dentists, psychologists and other academic staff, 2) physiotherapists, midwives, medical laboratory technologists, social workers and alike, 3) nurses, 4) medical secretaries, office, IT and administrative workers, 5) nursing assistants, 6) cleaning personal, hospital porters, and various assistants.

Statistical analysis

The incident number of absence spells (any spells, short, medium and long spells) was examined in Poisson regression models allowing for overdispersion and with the logarithm of days at risk as offset. Rate ratios (RR) and their asymptotic 95% confidence intervals (CI) for model covariates were estimated on a log-scale and back transformed. The dichotomous outcome abnormal versus normal absence was examined in logistic regression analyses, calculating odds ratios (OR) and their asymptotic 95% CI.

We analysed the different sickness absence outcomes in regression models with demands, control, support, and multiplicative interaction terms for strain (demands*control) and iso-strain (demands*control*support) forced into the model. For short, medium and long spells we adjusted for spells of other duration than the outcome in question (e.g. for short spells, we adjusted for the presence (yes/no) of medium spells and of long spells). For abnormal sickness absence we adjusted for days at risk. These covariates and age, gender

and work unit were retained in all models. Preliminary analyses showed no gender interaction effects with the other covariates. The clustering in work units was taken into account by multilevel modelling in a mixed model. We further included occupational group, work time and schedule factors, psychosocial factors, personal factors and general health as covariates. For each outcome, these latter covariates were successively eliminated in a backwards procedure, the least significant first, if not significant at $p<0.05$. In the resulting model each covariate was then re-introduced, one by one, and if significant it was retained in the model.
Demands, control and support were analysed as continuous variables with values from 1 to 5. The demands*control interaction term was adjusted to the same range by division by 5, and the demands*control*support interaction term was similarly adjusted by division by 25. In this way the effect size of a one unit increase of the main and interaction effects all refer to a scale of 5 units. Analyses were made with PROC GLIMMIX, SAS (9.1).

Results

The mean age of the study population was 44 years; nurses were on average the youngest occupational group. Eighty-four percent of the study population were women. Gender was unequally distributed in the occupational groups; the groups of nurses, physiotherapists and medical secretaries consisted of nearly only women (95-96%) and except for the doctors group (42% women) the other groups consisted mostly of women (59-86%). Five percent reported poor general health, from 3% of the doctors to 10% among the cleaners/porters group. Among the 2331 participants, 1889 (81%) had at least one sickness absence spell during the follow-up year. Related to the total calculated days at risk, the sickness absence rate was 6.1 %. The median number of absence days was 9 and the median number of absence spells was 3.0. It appears from figure 1 that there was a large overlap between absences of different duration.

Table 1 shows the characteristics of sickness absence by age, gender, health and occupational group. Women had more of all types of absences than men. The group of 50-59 years-old had fewer absences of short and medium duration and less abnormal absence than the younger groups. Persons reporting poor health had more of all types of absences than people reporting good health. Differences between the occupational groups were obvious. Fewer from the higher SES-groups had absences, regardless of the measure of absence. The cleaners/porters group differed from the other groups in having comparatively much more absence of medium duration.

Table 2 shows the distribution of sickness absence by categories (rounded units) of demands, control and support, and of strain and iso-strain. In this context strain was defined as the mean of demands and control, and iso-strain as the mean of demands, control and support. Very few stated that they had either very high or very low degrees of demands and control, and very few complained of a very low degree of support at work. Any absence lasting >14 days and abnormal absence increased significantly with categories of control ($p=0.04$ and $p=0.02$, respectively) and any absence lasting >14 days increased significantly with categories of strain ($p=0.04$) in these bivariate analyses. Otherwise, there were no significant trends connecting an increase in sickness absence with increasing levels of DCS variables.

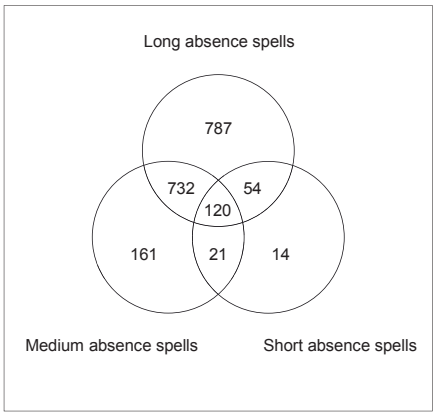

Figure 1.
Distribution of sickness absence spells of different durations. Short absence spells = 1-3 days. Medium absence spells = 4-14 days. Long absence spells >14 days.

Table 1. Sickness absence characteristics by age, gender, health and occupational group.

	Total	Any absence	No. of absence days per person per year at risk	No. of absence spells per person per year at risk	Any absence of 1-3 days	Any absence of 4-14 days	Any absence of >14 days	Abnormal absence pattern	Days at risk
	N	n(%)	median days	median spells	n(%)	n(%)	n(%)	(%)	mean (SD)
Age									
20-29	235	191 (81%)	10	4.00	175 (74%)	106 (45%)	22 (9%)	115 (49%)	173 (64)
30-39	628	512 (82%)	9	3.14	469 (75%)	299 (48%)	41 (7%)	266 (42%)	182 (62)
40-49	715	596 (83%)	8	3.07	527 (73%)	318 (44%)	69 (10%)	290 (41%)	193 (55)
50-59	753	590 (78%)	8	2.05	522 (69%)	311 (41%)	77 (10%)	248 (33%)	200 (47)
Gender									
Women	1954	1610 (82%)	9	3.07	1443 (74%)	884 (45%)	190 (10%)	796 (41%)	190 (55)
Men	377	279 (74%)	7	2.06	250 (66%)	150 (40%)	19 (5%)	123 (33%)	189 (61)
General health									
Poor*	121	106 (88%)	13	5.11	97 (80%)	69 (57%)	24 (10%)	68 (56%)	178 (64)
Good**	2177	1757 (81%)	8	3.03	1573 (72%)	949 (44%)	178 (8%)	836 (38%)	191 (55)
Occupational groups									
Doctors	258	159 (62%)	3	1.06	149 (58%)	40 (16%)	9 (3%)	40 (16%)	168 (71)
Physio-therapists	294	216 (73%)	7	2.06	207 (70%)	90 (31%)	21 (7%)	99 (34%)	198 (52)
Nurses	710	594 (84%)	8	3.07	538 (76%)	305 (43%)	62 (9%)	284 (40%)	191 (55)
Medical secretaries	328	269 (82%)	8	3.01	248 (76%)	149 (45%)	23 (7%)	132 (40%)	191 (56)
Nursing assistants	491	437 (89%)	11	4.05	386 (79%)	290 (59%)	71 (14%)	247 (50%)	191 (52)
Cleaners/ porters	250	214 (86%)	12	3.05	165 (66%)	160 (64%)	23 (9%)	117 (47%)	197 (50)
Total	*2331*	*1889 (81%)*	*9*	*3.04*	*1693 (73%)*	*1034 (44%)*	*209 (9%)*	*919 (39%)*	*190 (56)*

*General health rated as "less good" or "poor". **General health rated as "excellent", "very good" or "good".

Table 3 shows the adjusted RRs and ORs for effects of demands, control, and support, and of the strain and iso-strain interaction terms on the number of all spells, short, medium and long spells, and on abnormal absence. For each of these outcomes we show the results of three models, all adjusted for age, gender and work unit. Model 1 shows the effects of demands, control and support without mutual adjustment. Model 2 shows main and interaction effects mutually adjusted; and the final model shows the three main effects and significant interaction effects, mutually adjusted and adjusted for other significant covariates.

There were no significant interactions in the analyses of all spells, long spells and abnormal absence. For these outcomes, the effect of decreasing control was an increase in sickness absence, significantly so for all spells and for abnormal absence, but only in Model 1, and there were no significant effects of demands or support. There was a significant three-way interaction between demands, control and support for short spells and a significant two-way interaction between demands and control for medium spells. When these interactions were taken into account, the main effect of support changed direction in the analyses of short spells, and the main effects of

Table 2. Sickness absence characteristics by the demand-control-support stress model variables.

Stressor (mean(SD))	Total	Any absence	Any absence of 1-3 days	Any absence of 4-14 days	Any absence of >14 days	Abnormal absence pattern	No. of absence days per person per year at risk	No. of absence spells per person per year at risk	Days at risk
	N	n(%)	n(%)	n(%)	n(%)	n(%)	median	median	mean (SD)
Demands (3.17 (0.54))									
1.33 - <1.50	2	1 (50%)	1 (50%)	1 (50%)	0 (0.0%)	1 (50%)	10.6	2.2	218 (13)
1.50 - <2.50	246	194 (79%)	175 (71%)	104 (42%)	22 (8.9%)	100 (41%)	6.5	3.1	194 (54)
2.50 - <3.50	1383	1127 (81%)	1000 (72%)	628 (45%)	122 (8.8%)	534 (39%)	7.2	3.0	191 (55)
3.50 - <4.50	681	549 (81%)	500 (73%)	294 (43%)	61 (9.0%)	277 (41%)	7.8	3.1	188 (59)
4.50 - 4.83	10	10 (100%)	10 (100%)	3 (30%)	2 (20%)	4 (40%)	10.6	3.0	193 (62)
		p-trend=0.54	p-trend=0.25	p-trend=0.68	p-trend=0.75	p-trend=0.72			
Control (2.54 (0.58))									
1.00 - 1.50	53	41 (77%)	37 (70%)	26 (49%)	2 (3.8%)	18 (34%)	6.0	3.0	205 (43)
1.50 - <2.50	1053	854 (81%)	760 (72%)	439 (42%)	83 (7.9%)	379 (36%)	7.0	2.3	194 (53)
2.50 - <3.50	1058	859 (81%)	774 (73%)	486 (46%)	103 (9.7%)	456 (43%)	8.1	3.1	187 (58)
3.50 - <4.50	128	100 (78%)	92 (72%)	59 (46%)	12 (9.4%)	49 (38%)	7.5	3.0	181 (67)
4.50 - 5.00	6	5 (83%)	4 (67%)	3 (50%)	2 (33%)	1 (17%)	10.7	3.3	146 (75)
		p-trend=0.82	p-trend=0.74	p-trend=0.10	p-trend=0.04	p-trend=0.02			
Support (2.24 (0.74))									
1.00 - 1.50	399	333 (83%)	304 (76%)	175 (44%)	24 (6.0%)	147 (37%)	7.0	3.0	193 (52)
1.50 - <2.50	1118	897 (80%)	804 (72%)	491 (44%)	102 (9.1%)	424 (38%)	7.0	3.0	191 (55)
2.50 - <3.50	657	538 (82%)	478 (73%)	307 (47%)	67 (10%)	297 (45%)	9.0	3.1	188 (57)
3.50 - <4.50	118	89 (75%)	79 (67%)	50 (42%)	12 (10%)	39 (33%)	6.5	3.0	186 (65)
4.50 - 5.00	8	6 (75%)	6 (75%)	0 (0.0%)	1 (13%)	3 (38%)	5.3	3.3	160 (79)
		p-trend=0.29	p-trend=0.19	p-trend=0.95	p-trend=0.06	p-trend=0.10			
Strain* (2.85 (0.33))									
1.67 - <2.50	313	261 (83%)	233 (74%)	151 (48%)	20 (6.4%)	123 (39%)	7.0	2.8	195 (52)
2.50 - <3.50	1933	1554 (80%)	1390 (72%)	841 (44%)	177 (9.2%)	759 (39%)	7.1	3.0	190 (56)
3.50 - <4.18	76	66 (87%)	63 (83%)	38 (50%)	10 (13%)	34 (45%)	10.0	3.5	177 (67)
		p-trend=0.79	p-trend=0.68	p-trend=0.48	p-trend=0.04	p-trend=0.59			
Iso-strain** (2.65 (0.38))									
1.53 - <2.50	821	671 (82%)	598 (73%)	372 (45%)	62 (7.6%)	308 (38%)	7.0	2.9	194 (52)
2.50 - <3.50	1458	1178 (81%)	1058 (73%)	643 (44%)	140 (9.6%)	593 (41%)	8.0	3.1	189 (57)
3.50 - <3.99	45	33 (73%)	31 (69%)	16 (36%)	5 (11%)	16 (36%)	6.0	3.1	169 (74)
		p-trend=0.32	p-trend=0.73	p-trend=0.33	p-trend=0.08	p-trend=0.24			
Total	*2331*	*1889 (81%)*	*1693 (73%)*	*1034 (44%)*	*209 (9%)*	*919 (39%)*	*9.0*	*3.04*	190 (56)

* Mean of demands and control. ** Mean of demands, control and support

Table 3. Rate ratios (RR) or odds ratios (OR) and 95% confidence intervals (CI) for effects of the demands-control-support model variables on sickness absence spells.

Multiple Poisson or logistic regression analyses. RR and OR are risk estimates for a one unit increase on scales from 1 to 5 for all variables. Model 1: Each main variable separately, no mutual adjustment. Model 2: Main variables and their interactions, mutually adjusted. Final model: Main variables and significant interactions, mutually adjusted. See footnotes on adjustment for effects of other covariates.

	All spells			Short spells (1-3 days)			Medium spells (4-14 days)			Long spells (> 14 days)			Abnormal absence		
	Model 1	Model 2	Final model	Model 1	Model 2	Final model	Model 1	Model 2	Final model	Model 1	Model 2	Final model	Model 1	Model 2	Final model
	RR (95% CI)			RR (95% CI)			RR (95% CI)			RR (95% CI)			OR (95% CI)		
Demands	1.07 (0.99-1.16)	0.76 (0.54-1.08)	1.03 (0.94-1.12)	1.08 (1.00-1.18)	0.99 (0.69-1.41)	1.09 (0.77-1.56)	1.01 (0.90-1.14)	0.46 (0.27-0.77)	0.58 (0.36-0.95)	1.19 (0.84-1.69)	1.39 (0.28-6.81)	1,06 (0.71-1.58)	1.04 (0.87-1.24)	0.45 (0.21-0.96)	1,07 (0.88-1.31)
Control	1.13 (1.05-1.22)	0.74 (0.49-1.11)	0.97 (0.89-1.06)	1.10 (1.02-1.19)	0.99 (0.64-1-51)	1.09 (0.72-1.66)	1.08 (0.97-1.20)	0.40 (0.22-0.74)	0.42 (0.23-0.74)	1.19 (0.86-1.64)	1.33 (0.21-8.58)	0,96 (0.65-1.42)	1.19 (1.02-1.40)	0.42 (0.17-1.04)	0,98 (0.80-1.19)
Support	1.06 (1.00-1.12)	0.84 (0.68-1.03)	0.97 (0.91-1.03)	1.05 (0.99-1.11)	0.82 (0.66-1.02)	0.78 (0.63-0.97)	1.04 (0.96-1.13)	1.01 (0.75-1.38)	0,96 (0.87-1.05)	1.21 (0.95-1.55)	1.14 (0.44-2.94)	1,15 (0.86-1.53)	1.08 (0.96-1.23)	0.99 (0.61-1.60)	0,99 (0.86-1.15)
Strain*		1.54 (0.72-3.29)	-		0.92 (0.42-2.02)	0.64 (0.29-1.40)		4.75 (1.52-14.84)	3,31 (1.32-8.33)		0.76 (0.02-24.27)	-		5.00 (0.93-26.94)	-
Iso-strain**		1.81 (0.98-3.35)	-		1.88 (0.99-3.55)	1.94 (1.04-3.61)		1.02 (0.41-2.53)	-		1.14 (0.07-17.32)	-		1.15 (0.28-4.78)	-

* multiplicative interaction term demands*control/5, see text. ** multiplicative interaction term demands*control*support/25, see text.

All models adjusted for age, gender, and work unit. Further adjustment:

Model 1 and 2, all spells: None. *Model 1 and 2, short, medium and long spells*: Absences of other lengths. *Model 1 and 2, abnormal absence*: Days at risk. *Final model, all spells*: SES, special duty responsibilities, violence, job satisfaction, full time work, being single, general health. *Final model, short spells*: Absences of other lengths, SES, special duty responsibilities, job satisfaction, full time work, being single, general health. *Final model, medium spells*: Absences of other lengths, SES, special duty responsibilities, job satisfaction, being single, general health. *Final model, long spells*: Absences of other lengths, special duty responsibilities, general health. *Final model, abnormal absence*: Days at risk, SES, special duty responsibilities, full time work, being single, general health.

demands and control changed direction in the analyses of medium spells, indicating rather complex interactions. These are best understood from a graphical representation of the risk estimates associated with different levels of the interacting variables (figure 2 and 3). These estimates were calculated from the effect estimates of the final models (Table 3) and adjusted relative to an effect of unity at the lowest level of demands and highest level of control and support. According to the job strain and iso-strain hypotheses (9) this level would result in the lowest level of work-related stress and stress-related outcomes. Consequently, the risk of sickness absence should increase from this level by increasing demands, and decreasing control and support. As shown in figure 2 and 3, the pattern of risk estimates of combined effects of the DCS

variables was not in accordance with these expectations.

Discussion

In this 1-year follow-up study we found no support for the hypothesis that sickness absence increases with work-related stress in terms of high demands, low control and low support at work, or that the simultaneous presence of these factors have an especially strong effect on sickness absence. This was the case for any sickness absence, for sickness absence of short duration (1-3 days), medium duration (4-14 days) and long duration (>14 days), and for an abnormal sickness absence pattern.

There were no significant interaction effects between DCS variables on all spells, long spells or abnormal absence. For sickness absence of short duration we found a significant interaction between demands, control, and support, and for sickness absence of medium duration we found a significant interaction between demands and control. However, the pattern of effects of combinations of different levels of demands, control and support, did not fit with the predictions of the DCS model (figure 2 and 3). To fit with these predictions the main effects (RR or OR) must not be below unity and the effect of the interaction term must be above unity when estimated in the same model. This was not the case as shown in table 3.

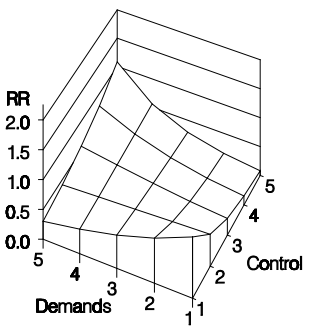

Figure 2. Rate ratios (RR) of medium sickness absence spells by combinations of demands and control.
The RRs are relative to a RR=1 for the lowest level of demands (score=1) and the highest level of control (score=1). For the highest level of demands (score=5) and the lowest level of control (score=5) the RR was 1.08. All other RR's were below unity.

We analysed the effects of demands, control and support as linear effects including interaction terms, utilising the whole range of scale scores. This is in accordance with a number of other studies(10-13;29). Most studies, however, used median split dichotomies of the DCS variables to study effects of strain and iso-strain(4;14;15;18-22;24;25;27;28). However, the results from these studies are difficult to compare since the median scores and distributions above and below the median are seldom reported.

We made sure that sickness absence was recorded only during the period that the person was part of the same work unit as when the questionnaire on exposures was completed, and the follow-up period was limited to maximum 1 year. These restrictions were made to increase the validity of psychosocial work environment measures as predictors of sickness absence. If the follow-up time is longer it is more likely that the work environment will change due to all kinds of economic and organisational changes.

Sickness absence was recorded from administrative data and are believed to be complete and with only few errors. They are recorded by the work units on a daily basis together with other types of absences and reported weekly. We analysed the number of absence spells in relation to days at risk of a new absence spell. Days at risk was precisely calculated. However, we only knew the number of work days, not the specific dates of planned work. This could be a problem, especially in a hospital setting where extended duties and night duties may be compensated by more days off and consequently fewer days at risk than we have calculated. However, we believe that this problem will only affect a small proportion of persons and planned work days.

Sickness absence of different durations may have different risk factors(4;32). We therefore divided absences into short, medium and long absences. We hypothesized that work related stress as measured by the DCS variables would have a tighter relation to short absences than longer absences but since we found no significant associations this hypothesis was not confirmed.

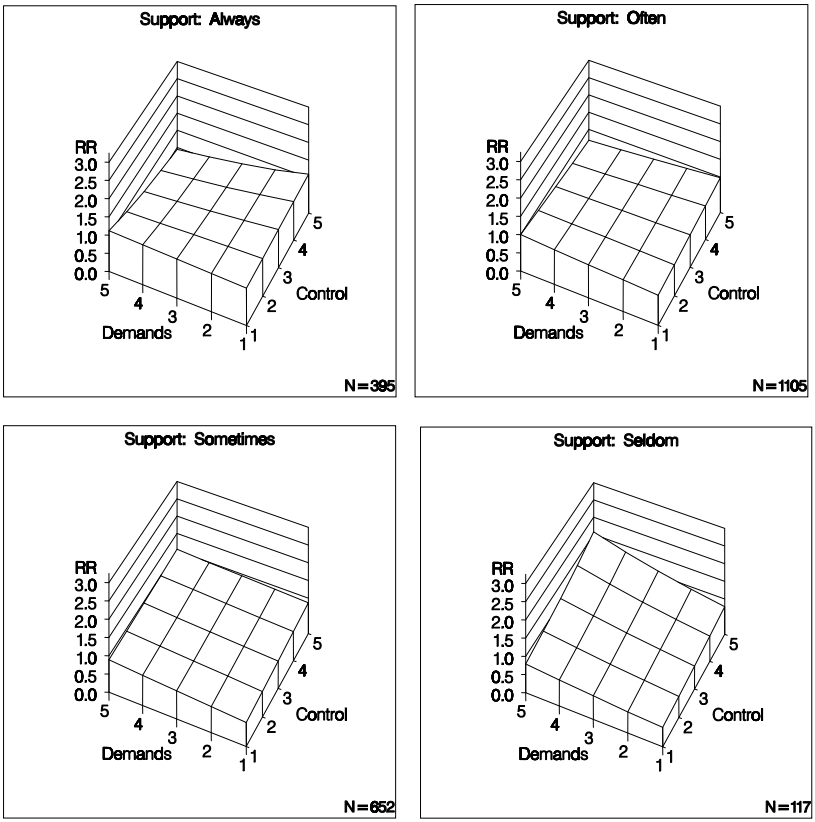

Figure 3. Rate ratios (RR) of short sickness absence spells by combinations of demands, control and support.
(A panel for "Support: never" is not included since only 8 persons reported such a low level of support.)
The RRs are relative to a RR=1 for the lowest level of demands (score=1), the highest level of control (score=1) and the highest level of support (always available), upper left panel, front corner. When support is always or often available, the combination of high demands (score=5) and low control (score =5) reduces the risk of short sickness absence (upper panels, back corner).
When support is only sometimes or seldom available, the same combination increases the risk (lower panels, back corner). If demands are low (score=1) and control is high (score=1), low support decreases the risk (lower panels, front corner).

Only a few previous prospective studies examine sickness absence of different duration in relation to strain. The results of these studies are not very consistent(4;5;11;14;16;18;20;24).
We hypothesized that a few absences caused by e.g. a flue, a broken leg or appendicitis was quite normal and less likely to be influenced by work stress than more frequent absences. We arbitrarily defined such a pattern of abnormal sickness absence, but it was not associated with strain or iso-strain. However, it showed a strong socioeconomic gradient in other analyses (data not shown). We have found no other studies of patterns of sickness absence. Possibly, the study of different patterns of sickness absence in relation to covariates could give more insight into the causes of sickness absence.

There was a large overlap between sickness absences of different duration (figure 1). To disentangle risk factors for sickness absences of a certain duration from those of overlapping absences of different durations the effects of the latter absence type must be controlled for in the analyses.

However, we found only two other studies that addressed this problem(32;38).

We examined if other psychosocial work environment factors, work schedule factors, personal factors and general health were significantly associated with sickness absence outcomes. If so, we included these factors in the final models to adjust for potential confounding.
In principle, some of these factors could act as mediators of effects of DCS variables, and if so, their effects should not be controlled for in the analyses. Only a few factors showed significant effects, notably job satisfaction, general health and SES (significant covariates are listed below table 3). We checked for overadjustment by excluding job satisfaction and general health in the final models, but the results were approximately the same (data not shown). It is unlikely that SES may act as a mediator of DCS effects on sickness absence. It has been claimed that adjustment for SES may be overadjustment for effects of DCS variables, particularly so for control(39). However in our study SES was only weakly associated with the DCS variables.

Limitations of the study include its generalizability, being a study of a single large hospital. Also, we would have preferred more information on medical and other reasons for absences, and exact dates on planned work days and sickness absence. Lack of information about specific physical workloads and about life style risk factors is also a shortcoming.

The study has several strengths. It was prospective, and sickness absence and risk time were objectively recorded and are assumed to be precise. The study design and data collection aimed at a generally constant work environment during the follow-up period. The DCS variables were analysed as continuous variables in models including multiplicative interaction terms, adjusting for a large number of potential confounders. Furthermore, the response rate was high, and differential non-response, therefore, is unlikely to affect the results.

The effect of strain and iso-strain on sickness absence has been examined in several other prospective studies. Most of these studies examined strain as the combined effect of demands and control without considering any interaction effects(4;14;15;19-22;24;25;27;28). One of the studies found no significant association between their strain measure and sickness absence(15); two studies found significant associations(21;22), and for five studies the results varied by type of sickness absence, gender or other stratification variables(4;14;19;20;24;25;27;28). Two studies examined iso-strain as the combined effect of demands, control and support without considering any interaction effects(4;18;20;28). One of these studies found an effect of iso-strain(18;20;28). These results, however, are difficult to interpret since a positive association between sickness absence and strain and iso-strain may be due to any of the DCS variables, to some of them or to all of them. On the other hand, the association may become weak and non-significant if one or more of the variables has a weak effect or no effect. Thus, if there are no interaction effects, an analysis of strain and iso-strain is not informative and may even conceal important information compared to an analysis of the independent and mutually adjusted effects of DCS variables.
We found six studies that examined the interaction effects between demands and control in relation to sickness absence(5;10-13;17;29) and four studies that examined interactions between demands, control and support(5;11;22;29). None of these studies found significant interactions between the DCS variables.
The results of our study are in accordance with other prospective studies examining interactions in the DCS model in relation to sickness absence. In our opinion, such interactions constitute the very core of the strain and iso-strain hypothesis. If there are no interactions, the theory of job strain and iso-strain reduces to the trivial hypothesis that work stress may result from three independent psychosocial factors, high demands, low control and low support at work. The central role of interactions in the job strain hypothesis has also been underlined by Karasek: “We can parsimoniously operationalize the job strain hypothesis with a single multiplicative product term (an interaction) based on equally weighted scales of psychological job demands and job decision latitude.”(30) Our analyses and interpretations are in line with this short statement.

A theory gains credibility if it is not falsified. In relation to sickness absence, the job strain and iso-strain theory of job stress seems to be consistently falsified since no studies have found significant interactions in accordance with the theory. This message, however, has been obscured by the reporting of some "supporting" results based on analyses of combined effects of DCS variables without considering their interactions.

Conclusion

Sickness absence was not related to the DCS stress model in this study, regardless of absence duration and pattern. In particular, there was no interactions compatible with the model. The results are consistent with the results of other similar prospective studies. Thus, the strain and iso-strain hypotheses in relation to sickness absence are not supported by data from observational studies.

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APPENDIX

Overall demand scale (Cronbach α: 0.81)
Quantitative demands (workload) *(Cronbach α: 0.68)*
Do you have to work very fast? *
Is your workload unevenly distributed so it piles up? *
How often do you not have time to complete all your work tasks? *
Do you have to do overtime? *

Cognitive demands *(Cronbach α: 0.75)*
Do you have to keep your eyes on a lot of things while you work? *
Does your work require that you remember a lot of things? *
Does your work demand that you are good at coming up with new ideas? *
Does your work require you to make difficult decisions? *

Emotional demands *(Cronbach α: 0.82)*
Does your work put you in emotionally disturbing situations? *
Is your work emotionally demanding? **
Do you get emotionally involved in your work? **

Control scales (Cronbach: α 0.78)
Decision authority *(In COPSOQ labelled "Influence at work") (Cronbach: α 0.77)*
Do you have a large degree of influence concerning your work? *
Do you have a say in choosing who you work with? *
Can you influence the amount of work assigned to you? *
Do you have any influence on how you do your work? *
Do you have any influence on what you do at work? *

Skill discretion (In COPSOQ labelled "Possibilities for development") *(Cronbach: α 0.73)*
Is your work varied? *
Does your work require you to take the initiative? **
Do you have the possibility of learning new things through your work? **
Can you use your skills or expertise in your work? **

Social support (Cronbach: α 0.81)
How often do you get help and support from your colleagues? *
How often are your colleagues willing to listen to your work related problems? *
How often do you get help and support from your immediate superior? *
How often is your immediate superior willing to listen to your work related problems? *
Can you get the professional support you need from your colleagues or from your superior? * [1)]

[1)] The last item in the social support scale did not originate from the COPSOQ, but was created for this study

Response categories
* always, often, sometimes, seldom, never/hardly ever
** to a very large extent, to a large extent, somewhat, to a small extent, to a very small extent

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Long term sickness absence: the relation to job strain and effort-reward imbalance - a prospective cohort study

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Objectives: We studied if long term sickness absence was influenced by work stress according to two popular stress models: Karasek's demand-control-support (DCS) model and Siegrist's effort-reward-imbalance (ERI) model.
Methods: 14.241 persons (70%) responded to a questionnaire sent to a random sample of the Danish core working force. Information about work factors and personal factors was obtained by the questionnaire and by record linkage with national registers. Objectively registered sickness absence data was obtained for the following 1½ year. After prior assessment of functional forms of the continuous covariates, the DCS and the ERI models were analysed, adjusting for a large number of potential confounders in complementary log-log (CLL) regression survival analyses with sickness absence spells >14 days as outcome.
Results: Eleven percent had at least one sickness absence spell >14 days. Regression analyses showed a significant effect of iso-strain, but the combined effects of demands, control and support were not in accordance with the DCS model. The effect of ERI increased at low levels and decreased at high levels of ERI, and there was no interaction with overcommitment.
Conclusion: The results were not in accordance with the model hypotheses. High job demands, high efforts and low rewards, however, may have small independent effects after adjustment for effects of other factors.

Keywords: sick leave, absenteeism, demand-control-support model, work stress, interaction

In the last decade sickness absence has become a topic of increasing political concern in many developed countries. Owing to a lack of labour during the economic boom in the first years of this century the reduction of sickness absence became a high priority of the Danish government. In Denmark, a total of 5% of all work days are lost due to sickness absence, and sickness absence spells lasting more than 14 calendar days accounts for 60% of the absence.
Sickness absence is a complex phenomenon with a large number of risk factors related to the person, the work place and society at large. Several studies indicate that a poor psychosocial work environment and work related stress is associated with increased sickness absence, including long term sickness absence.[1-7]
For many years, Karasek's demand-control-support (DCS) model[8, 9] and Siegrist's effort-reward imbalance (ERI) model[10] have been the predominant theoretically based occupational stress models.
The DCS model claims that high demands at work are harmful to health if they are not accompanied by a high

level of control at work. The combination of high demands and low control is termed job strain. The model further claims that job strain is particularly harmful if social support at work is low. This situation is termed iso-strain.[9] The hypotheses that the effect of demands depends on the level of control and that the effect of strain depends on the level of support is equivalent to a hypothesis of a three-way interaction between the basic variables of the model

According to the ERI model work stress occurs when more efforts are spent than rewards received. ERI is measured as the ratio between effort and reward and increases with increasing effort and decreasing reward. The model further claims that the adverse health effects of ERI increase if the person is overcommitted to work.[10] The hypothesis of an increased effect of ERI in the presence of high overcommitment is a hypothesis of an interaction between the two variables.

The two stress-models have been widely used to study a range of adverse health outcomes, including sickness absence. However, the interaction effects specified in the models are often not examined, and their effects on a specific outcome have seldom been examined in the same study. Furthermore, the effects of the two stress models in relation to long term sickness absence have only been studied to a very limited degree.

The present study examines the effects of the DCS and ERI models on long term sickness absence, defined as absence spells lasting more than 14 calendar days. The effects of the two models were mutually adjusted and their hypotheses of interactions were tested.

METHODS

The study population was a random sample of the Danish core work force, defined as persons who had been employed for at least 80% of the time during the previous year. In the autumn of 2004, a postal questionnaire was sent to 20.464 persons, of whom 14.241 (70%) returned a completed questionnaire. Of the responders 50.5 % were men and 49.5 % women. The mean age was 43.7 years (19-64 years). There was a slight underrepresentation among responders of men, age group 19-29 years, and persons of lower social status.

Sickness absence

Data on sickness absence was obtained from a national register on social transfer payment, the DREAM register, during a period of 1.5 years (79 weeks) from the date of completing the questionnaire. The DREAM register contains information on sickness absence spells exceeding two weeks (14 calendar days).[11]

Job strain and effort-reward imbalance

Each of the basic constructs of the DCS model (job demands, decision latitude and social support) was measured with one or two global items. These items were originally developed as part of a short form questionnaire of psychosocial exposures used as an addendum to a questionnaire on indoor climate.[12] "How demanding do you feel your work is, all in all?" measured psychological demands, "How much influence do you normally have on the organisation and execution of your work?" measured decision authority, and "Do you find your work stimulating, educational and involving?" measured skill discretion. Social support from colleagues and supervisors were measured with two single items "If you have problems with your work, can you obtain the necessary help and support from your colleagues?" and "If you have problems with your work, can you obtain the necessary help and support from management?" All global single items had 6 verbally anchored response categories scored 1-6 by increasing intensity or frequency. A work control scale was constructed by taking the mean of the decision authority and skill discretion items, and a support at work scale was calculated as the mean of the two single items measuring support. We validated in separate studies the global single items against the multi-item scales measuring the same constructs in the first version of the COPSOQ.[13] Correlations between the global single items and the corresponding scales were moderate to high (Spearman correlations from 0.48-0.69). Furthermore correlations with 33 other variables, with which we expected the correlations to be low (e.g. gender, age, pain) as well as moderate to high (e.g. job satisfaction, quality of management, responsibility at work), were generally very similar for the global single items and the corresponding scales (to be published separately).

ERI was measured with a short version of the effort-reward standard questionnaire and contained 3 items measuring effort and 7 items measuring reward,[14]

each with 5 response categories (see appendix). The questionnaire was translated from the English version and back translated to confirm the accuracy of the original translation. ERI was calculated as the ratio between the mean of effort item scores and the mean of reversed reward item scores and is then a measure that increases with high efforts and low rewards.[15] Overcommitment was measured with a 6 item scale, each with 4 response categories (from completely agree to completely disagree) scored 1-4 with high values indicating high overcommitment[14] (see appendix).

Other covariates

A large number of covariates were a priori considered as potential confounders. They are all shown in table 1. All scale values were calculated as the mean of item scores. If half or more items in a scale were missing, the scale value was set to missing.

Statistical analysis

Data were analysed by complementary log-log (CLL) regression for interval-censored survival times where the time variable (week) was included in the model as an indicator variable. The CLL model is a discrete analogue of the continuous proportional hazards model. The outcome was the first episode of sickness absence exceeding 14 calendar days. Risk time was calculated as the time from completing the questionnaire to the week of the first sickness absence period of >14 days, or to the week of retirement, death or emigration or to the end of follow-up after 79 weeks, whichever came first. Periods with unemployment were subtracted from the risk time. Hazard ratios (HR) and their 95 % confidence interval (CI) were calculated.

As the study included many covariates, the analyses were made in two steps. First, different models with groups of "similar" covariates were analysed to decide which covariates should be included in a full model. The groups were 1) the effort-reward model, 2) the job strain model, 3) socioeconomic status, 4) other work related exposures and 5) personal conditions (see table 1). Covariates from each group were first excluded by backward selection, excluding the least significant covariates first. In the resulting model, excluded variables were then re-introduced in the model, one by one, to see if they had a significant effect in this model after correction for multiple comparisons using the Benjamini-Hochberg-procedure.[16] The level of statistical significance was set to $p<0.05$. Next, the remaining significant covariates from all the groups were included in a full model and the same model selection procedure was applied to arrive at a final model with explanatory variables with significant independent effects on sickness absence. All models included age and gender. Interactions between demands, control and support were examined by including a multiplicative job strain term (demands*control) and iso-strain term (demands*control*support) in the model together with the main variables. Interaction between ERI and overcommitment was examined by the inclusion of a multiplicative term (ERI*overcommittment) together with the main variables.

Data were analysed with SAS statistical software. The functional form of continuous covariates was assessed with the ASSESS statement in PROC GENMOD and appropriate transformations (e.g. log, square-root or exponential) were made if a linear effect was not accepted. Analyses were made with PROC GENMOD using the link CLOGLOG.

RESULTS

Sixty-nine percent of the population was followed during all the 79 weeks. Eleven percent (1571 persons) had at least one sickness absence spell of >14 days, and the remaining 20% were censored during the follow-up time due to other reasons than sickness absence. Thirteen percent of women had a sickness absence spell >14 days, and 9.2 % of men. There were significant differences between the age groups, with increasing sickness absence with older age. However, the group of 60-64 years old had less absence than the 40-49 years and the 50-59 years, probably owing to a healthy worker effect related to early retirement benefits from the year of 60. For all measures of socioeconomic status, there were significant trends indicating that lower social groups had more absence.

The bivariate distribution of sickness absence by DCS and ERI variables is shown in table 2. There were highly significant trends for all associations. Few persons reported very low demands, very low or very high strain and iso-strain, and very low reward and high ERI. The functional form of the relations between sickness absence and the DSC and ERI variables were accepted as linear except for ERI, see below.

Table 1. Covariates included as potential confounders. Test for trend (Mantel_Haenzel's test) in cross tabulations with sickness absence (no/yes), and test for no effect on sickness absence in the final multiple regression model (see text). Source of covariates are shown in footnotes.

Group of covariate	Covariate	Measure	Cross-tabulation Test for trend	Test for no effect (HR=1) final model
Gender[1)]		Male / female	< 0.0001	0.0041
Age[1)]		10 year age groups	< 0.0001	0.28
Socioeconomic status[2)]	Highest education of the respondents' father	5 categories	0.0021	
	Highest education of the respondents' mother	5 categories	< 0.0001	
	Eriksson-Goldthorpe-Portocarero classes	6 categories	< 0.0001	< 0.0001
	Leadership, no. of subordinates	3 categories	< 0.0001	
	Highest attained education	5 categories	< 0.0001	
	Household income per adult	6 categories	< 0.0001	0.0003
	Own gross income	6 categories	< 0.0001	
Work related factors[3)]	Working hours per week	4 categories	< 0.0001	
	Overtime work	no/yes	< 0.0001	
	Only day work	no/yes	< 0.0001	
	Job tenure	single item 7 response categories	0.5308	
	Repetitive work	scale, 2 items	< 0.0001	
	Physically heavy work	scale, 2 items	< 0.0001	< 0.0001
	Job insecurity	single item 6 response categories	< 0.0001	
	Atmosphere at work	single item 6 response categories	< 0.0001	
	Satisfaction with leadership	single item 6 response categories	< 0.0001	
	Commuting	3 categories	0.24359	
	Work-family conflict	Scale, 3 items	< 0.0001	

1) Personal identification number

2) Statistics Denmark

3) Questionnaire

4) Interaction between 'single' and 'children at home'

5) Interaction between 'No of children living at home, aged 0-6', and gender

Table 1. continued

Group of covariate	Covariate	Measure	Cross-tabulation Test for trend	Test for no effect (HR=1) final model
Personal conditions	Municipal population density of residence[2)]	4 categories	< 0.0001	0.0006
	Cohabitation[2)]	single no/yes	0.3646	0.30
	Children at home[2)]	no/yes	0.0016	0.73
	Single with children at home[4)]		-	0.012
	No. of children living at home, aged 0-6[2)]	6 categories	< 0.0001	0.016
	No.of children living at home, aged 0-6, women[5]		-	0.0007
	Number of children living at home, aged 7-17[2)]	6 categories	0.21091	
	Satisfaction with family life[3)]	single item, 6 response categories	0.3110	
	Social support from family or friends[3)]	single item, 6 response categories	0.46592	
	Taking care of home[3)]	scale, 4 items	0.0002	
	Taking care of children	scale, 4 items	0.0374	0.016
	Visits to a doctor, physiotherapist or alike of the respondents spouse[2)]	2 categories	0.0061	
	Negative affectivity[3)]	single item, 7 response categories	0.0413	< 0.0001
	Type A behaviour[3)]	single item, 7 response categories	< 0.0001	
	Self efficacy[3)]	single item, 7 response categories	0.0322	
	Worry about health[3)]	scale, 2 items	< 0.0001	
	Somatization[3)]	scale, 3 items	< 0.0001	0.0050
	Attitude to sickness absence[3)]	scale, 7 items	0.1305	
	Visits to a doctor, physiotherapist or alike[2)]	5 categories	< 0.0001	< 0.0001
	General health[3)]	single item, 5 response categories	< 0.0001	< 0.0001
	Mental health[3)]	scale, 5 items	< 0.0001	
	Musculo-skeletal pain[3)]	scale, 4 items	< 0.0001	
	Perceived stress[3)]	scale, 4 items	< 0.0001	
	Number of chronic diseases[3)]	4 categories	< 0.0001	
	Work ability[3)]	visual analogue scale	< 0.0001	
	Smoking[3)]	2 categories	< 0.0001	0.048
	Alcohol consumption[3)]	3 categories	0.0034	
	Leisure time physical activity[3)]	2 categories	0.05218	
	Body mass index[3)]	< 30 kg/m^2 , ≥ 30 kg/m^2	< 0.0001	0.0030

1) Personal identification number, 2) Statistics Denmark 3) Questionnaire, 4) Interaction between 'single' and 'children at home', 5) Interaction between 'No of children living at home, aged 0-6', and gender

Covariate		Score	Total	Any sickness absence >14 days	
			N	n	%
Demands	low	1	80	5	6.3
		2	693	57	8.2
		3	2544	259	10.2
		4	5517	581	10.5
		5	4119	487	11.8
	high	6	1160	166	14.3
		Total	14113	1555	11.0
Control	high	1.0 - <1.5	1332	120	9.0
		1.5 - <2.5	5735	503	8.8
		2.5 - <3.5	4055	475	11.7
		3.5 - <4.5	1689	238	14.1
		4.5 - <5.5	717	129	18.0
	low	5.5 - 6.0	348	63	18.1
		Total	13876	1528	11.0
Support	high	1.0 - <1.5	2480	262	10.6
		1.5 - <2.5	4115	390	9.5
		2.5 - <3.5	3575	397	11.1
		3.5 - <4.5	1946	241	12.4
		4.5 - <5.5	1229	165	13.4
	low	5.5 - 6.0	678	89	13.1
		Total	14023	1544	11.0
Strain	low	1.0 - < 1.5	13	0	0.0
		1.5 - < 2.5	681	57	8.4
Mean of demands and control		2.5 - < 3.5	7487	684	9.1
		3.5 - < 4.5	4837	609	12.6
		4.5 - < 5.5	737	152	20.6
	high	5.5 – 6.0	109	24	22.0
		Total	13864	1526	11.0
Iso-strain	low	1.0 - <1.5	20	1	5.0
		1.5 - <2.5	2129	173	8.1
Mean of strain and support		2.5 - <3.5	7764	772	9.9
		3.5 - <4.5	3216	446	13.9
		4.5 - <5.5	593	115	19.4
	high	5.5 - 6.0	41	6	14.6
		Total	13763	1513	11.0
Effort	low	1.0 - <1.5	2043	179	8.8
		1.5 - <2.5	5172	496	9.6
		2.5 - <3.5	4199	438	10.4
		3.5 - <4.5	2086	306	14.7
	high	4.5 - 5.0	450	99	22.0
		Total	13950	1518	10.9
Reward	high	1.0 - < 1.5	4415	362	8.2
		1.5 - < 2.5	5569	591	10.6
		2.5 - < 3.5	2826	368	13.0
		3.5 - < 4.5	1000	170	17.0
	low	4.5 - 5.0	112	18	16.1
		Total	13922	1509	10.8
ERI	low	0.2 - <0.5	5148	451	8.8
		0.5 - <1.0	6032	618	10.2
		1.0 - <1.5	1751	253	14.5
		1.5 - <2.0	590	101	17.1
		2.0 - <2.5	182	44	24.2
		2.5 - <3.5	119	24	20.2
	high	3.5 - 5.0	32	7	21.8
		Total	13854	1498	10.8
Overcommitment	low	1.0 - <1.5	2004	182	9.1
		1.5 - <2.5	6439	660	10.3
		2.5 - <3.5	4687	570	12.2
	high	3.5 - 4.0	932	132	14.2
		Total	14062	1544	11.0

Table 2

Distribution of sickness absence by demand-control-support (DCS) and effort-reward-imbalance (ERI) model variables. A test for trend (Mantel_Haenzel's test) was significant ($p<0.0001$) for all cross tabulations. High scores indicate a high psychosocial load.

Table 3. Effects of the demand-control-support (DCS) and the effort-reward-imbalance (ERI) model variables. Hazard ratios (HR) and 95% confidence intervals (CI) for a one unit increase of covariates. Significant results are shown in bold. ns = not significant.

		Model 1		Model 2		Model 3		Model 4 Final model		Model 5 Alternative Final model		
	Range of scores	HR (95% CL)	P	HR (95% CL)	P	HR (95% CL)	P	HR (95% CL)	P		HR (95% CL)	P
Demand-control-support model												
Demands	1-6	**1.13** (1.07-1.19)	<.0001	**1.21** (1.14-1.27)	<.0001	1.13 (1.00-1.28)	0.058	1.00 0.87-1.16)	0.96	Demands	**1.07** (1.00-1.13)	0.048
Control	1-6	**1.27** (1.22-1.32)	<.0001	**1.32** (1.26-1.38)	<.0001	**1.19** (1.00-1.42)	0.049	0.95 0.77-1.16	0.59	Control	1.04 (0.98-1.11)	0.19
Support	1-6	**1.09** (1.05-1.13)	<.0001	1.00 (0.96-1.04)	0.98	1.08 (0.99-1.18)	0.073	1.04 0.95-1.15	0.42	Support	**0.95** (0.90-0.99)	0.031
Strain (demands* control)	1-36	-		-		1.044 (0.998-1.093)	0.063	1.048 0.994-1.105	0.085		-	
Iso-strain (strain* support)	1-216	-		-		**0.9936** (0.9874-0.9998)	0.042	**0.9921** (0.9851-0.9992)	0.029		-	
ERI model**												
ERI	0.20-5.00	**2.14** (1.69-2.71)	<.0001	**2.09** (1.63-2.67)	<.0001	**1.69** (1.20-2.39)	0.0029	**1.74** 1.31-2.31	<.0001	**Effort (1-5)**	**1.11** (1.03-1.18)	0.0040
ERI*ERI	0.04-25.0	**0.90** (0.84-0.97)	0.0053	**0.91** (0.84-0.98)	0.0087	**0.88** (0.81-0.96)	0.0026	**0.90** 0.83-0.98	0.015	**Rewards (1-5)**	**1.10** (1.01-1.19)	0.022
Over-commitment	1-4	**1.16** (1.08-1.24)	<.0001	1.03 (0.95-1.11)	0.48	0.94 (0.82-1.07)	0.34	ns	-		-	
ERI * over-commitment	0.20-20.0	-		-		1.118 (0.982-1.272)	0.093	ns	-		-	

Model 1: adjusted for age and gender, no interaction terms, no mutual adjustment. Model 2: as model1 but mutual adjustment separately for DCS and ERI variables. Model 3: as model 2, now including interaction terms. Model 4: Final model: adjusted for age and gender, mutually adjusted DCS and ERI variables in the same model, and adjustment for significant confounders. Model 5: Alternative final model with DCS main variables without interactions, and effort and rewards in stead of ERI, adjustment as for model 4.

Table 3 shows the results of the regression analyses. Sickness absence increased significantly with each of the three DCS-variables when analysed separately, adjusted only for age and gender. When their effects were mutually adjusted, support had no significant effect, and when the strain and iso-strain interaction terms were included the iso-strain term was significant. The significance of the iso-strain term means that the DCS variables in combination had a statistically significant influence on sickness absence, but that there was no specific separate effect of demands, of control or of support. The complicated pattern of effects of combinations of different levels of demands, control and support are best understood from plots of the estimated HRs associated with different levels of demands, control and support. From the HR-estimates in the final model in table 3 we calculated HRs for combinations of integer scores from 1 to 6 of demands, control and support and plotted the response surface of demands versus control by levels of support (figure 1). At high social support, a clear interaction pattern compatible with that of the strain hypothesis was seen for the combination of demands and control. However this pattern disappeared as social support became poorer and was even slightly reversed at the poorest level of support. This combined response pattern is opposite to the response pattern predicted by the DCS model.

The effect of ERI was modelled by a linear and a quadratic term due to a non-linear relationship between ERI and sickness absence. The combined effect of the linear and quadratic term increased until ERI = 2.6 and then decreased to approximately the same low level as for the lowest values of ERI. This pattern was consistent and significant in all models. This was also the case in analyses including all potential confounders in the final model, and whether DCS variables were included in the model or not**.** This response pattern is not in accordance with the ERI model. There was no significant effect of overcommitment and no significant interaction between ERI and overcommitment.

DISCUSSION

This study is a large prospective study of long term sickness absence in a random sample of the general Danish population. The size of the study allowed us to study a large range of potential risk factors for long term sickness absence. In the present paper we focus on the effects of two theoretically based generic stress models, the DCS model and the ERI model.

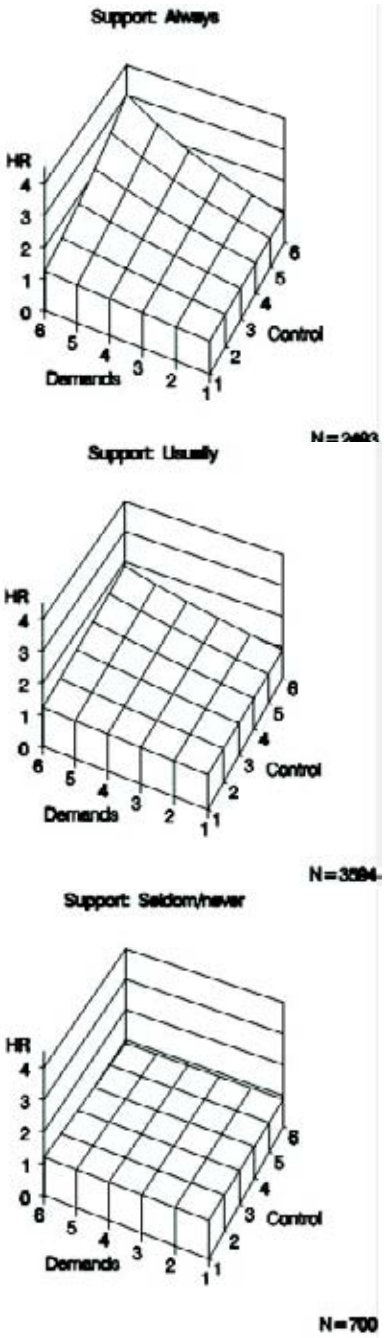
The core of the DCS stress model is the hypothesis that adverse effects of each of the demands, control and support constructs increase by increasing level of the other constructs. This effect modification, or interaction, is specified by the job strain and iso-strain concepts of the model. We found an effect of iso-strain which was consistently significant and of approximately the same order of magnitude in models with a varying degree of confounder control. However, the combined effects of demands, control and support on sickness absence were opposite to the response pattern predicted by the DCS model (figure 1).

Results from other prospective studies examining the association of strain and iso-strain with long term sickness absence (here defined as spells > 7 days) are not consistent.[3, 17-25]

However, none of these studies examined if there were interactions between demands and control (strain) or between strain and support (iso-strain). Instead they defined strain as the combination of high demands and low control, and iso-strain as the combination of high strain and low support. This analytical approach, however, cannot distinguish between an interaction effect and separate independent effects of the basic variables. If there are no interaction effects, it is not only sufficient but also more informative to report the separate effects of the basic variables instead of the effects of their combinations.

Sickness absence first increased and then decreased by increasing ERI. This was consistent and statistically significant in all models. Separately, overcommitment had a significant effect on sickness absence, but not in models adjusted for other ERI covariates, and there was no interaction between overcommitment and other ERI covariates. Altogether, these findings do not support the ERI model of job stress in relation to long term sickness absence. We found only one prospective study examining the effects of ERI on long absence spells (> 7 days).[26] This study found an increased risk of sickness absence with increasing ERI, but only for men. The effect of overcommitment was not examined.

The DCS results in the final model (table 3) changed only marginally if the ERI variables were excluded and vice versa (data not shown), and the effects of the two models on long term sickness absence therefore seem to be independent.



The study included a large number of factors expected to influence long term sickness absence. Most of these factors actually showed statistically significant associations with sickness absence (table 1) and were therefore considered as potential confounders in the analyses. In the final models we only included potential confounders which had a significant effect when adjusted for effects of other potential confounders. This adjustment, however, only marginally changed the effect estimates of the DCS and ERI variables (table 3). Health factors and behavioural factors could possibly act as mediators of effects of stressors at work. If so, their effects should not be controlled for. In separate analyses we excluded general health, visits to a doctor, BMI and smoking from the set of potential confounders in the final model, but the results for the DCS and ERI variables remained virtually unchanged (data not shown).

The iso-strain effect and the effect of the squared term of ERI were quite consistent and statistically significant in different models, but the p-values were not very low after adjustments in the final model (table 3). Considering the size of the study, the effect of iso-strain and the squared ERI term could be due to chance. We therefore also examined the effects of job strain (demands*control) in models without the iso-strain term. There were no significant effects of job strain in these models. We further substituted the ERI model terms with effort and

Figure 1

Hazard ratios (HR) of sickness absence by levels of demands, control and support. Three panels for support ("almost always", "often" and "sometimes") are omitted, since their response surfaces are in between their neighbouring panels.

The HRs are relative to a HR=1 for the lowest level of demands (score=1), the highest level of control (score=1) and the highest level of support ("always"), left panel, front corner.

When support is always available, the HR increases markedly for the combination of high demands (score=6) and low control (score=6), left panel, back corner. When support becomes poorer (middle and right panel) this pattern gradually disappears and the response surface becomes almost flat for the lowest level of support (right panel). For the lowest level of support, the HR for the combination of high demands (score=6) and low control (score=6) is slightly below unity (right panel, back corner).

rewards. For both of these variables a linear relation to sickness absence had been accepted. In a final model including the DCS-variables without interaction terms, and effort and rewards, there were small significant effects of demands, effort and rewards (table 3). There was no interaction between effort and rewards and no interactions with overcommitment.

Among the potential confounders in the final analyses, the two health variables and the two socioeconomic variables (table 1) were clearly the strongest predictors of long term sickness absence (data not shown). Among work related potential confounders only physically heavy work had an independent effect on long term sickness absence (table 1).

The strengths of our study include its prospective design, the large cohort representative of the Danish core working force with a large variety of occupations, the use of objectively registered sickness absence, and a fairly high response rate. Furthermore the DCS model and the ERI model were studied in the same study material, including interactions between demands, control and support and between ERI and overcommitment, and adjustment for effects of several potential confounders.

A limitation of the study is that the measures of DCS and ERI are not entirely comparable with other studies. However, the predictive validity of the DCS variables is supported by their significant bivariate associations with sickness absence in this study (table 2), and according to our validation studies the global single items measuring demands and control seem to be valid alternatives to corresponding multi-item scales. They were less reliable measures of the underlying constructs but this is not important in large sample studies. The sample size also compensates for the reduced number of items in the effort and reward scales.

We set out, a priori, to test the core hypotheses of the DCS and the ERI models in relation to long term sickness absence. Our results were not in accordance with predictions of the two models. The findings regarding the small independent effects of demands, effort and rewards should be considered as post hoc observations. Poor health and socioeconomic status were the major determinants of long term sickness absence.

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We thank Professor Johannes Siegrist for permission to use the abbreviated version of the ERI questionnaire.

APPENDIX

Effort scale (Cronbach α: 0.76)
How well do the following statements apply to you?
I am under constant pressure of time due to a heavy workload. *
I am often interrupted and disturbed in my work. *
In recent years, my work has become more and more demanding. *

Reward scale (Cronbach α: 0.80)
How well do the following statements apply to you?
I have experienced, or expect to experience, unwanted changes in my work. *
I am greatly at risk of being fired. *
I have poor prospects for promotion. *
I receive the respect I deserve from my superiors. **
When you take all my efforts and my performance into account, I receive all the respect and prestige I deserve in my work. **
My future prospects at work are in proportion to my efforts and performance. **
My salary/income is in proportion to my efforts and performance at work. **

Response categories:
* Agree, it doesn't bother me/ agree, it bothers me slightly/ agree, it bothers me somewhat/ agree, it bothers me a lot
* *Disagree, it doesn't bother me/ disagree, it bothers me slightly/ disagree, it bothers me somewhat/ disagree, it bothers me a lot

Overcommitment scale (Cronbach α: 0.78)
How well do the following statements apply to you?
I am often short of time when I work.
When I wake up, the first thing I think of is often my work.
When I get home from work, it is easy for me to relax and let go.
People who know me well say I make too many sacrifices for my work.
I am never finished with my work. Even in the evenings, I often think about it.
If I postpone something I should have done today, I have trouble sleeping at night.

Response categories:
Strongly disagree/ partially disagree/ partially agree/ totally agree

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