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# Socioeconomic status and sick leave granted for mental and somatic disorders: a prospective study of young adult twins

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## Abstract

**Background:** Low socioeconomic status (SES), indicated by low income and education, has consistently been found to be a strong predictor of sick leave. Several possible pathways from SES to sick leave have been described in previous literature, but there are also evidence indicating that the association can be confounded by common underlying factors. This study utilizes a population-based sample of employed young adult twins to estimate (i) the degree to which education and income are prospectively related to sick leave granted for mental, somatic, and any disorder, and (ii) whether these associations are confounded by familial factors.

**Methods:** Registry data on educational attainment and income at age 30 and subsequent sick leave were available for 6,103 employed young adult twins, among which there were 2,024 complete twin pairs. The average follow-up time was 6.57 years. Individual-level associations and fixed effects within twin pairs were estimated.

**Results:** Low education and income were associated with sick leave granted for both mental and somatic disorders, and with sick leave granted for any disorder. Associations were attenuated within dizygotic twin pairs and reduced to non-significance within monozygotic twin pairs, suggesting influence of familial factors on the associations between SES and sick leave.

**Conclusions:** Low SES is associated with a higher level of sick leave granted for both mental and somatic disorders among young adults, but these associations are confounded by factors that are common to co-twins. Education and income are therefore not likely to strongly affect sick leave in young adulthood.

**Keywords:** Sick leave, Education, Income, Health inequalities, Twin study, Norway

## Background

Sick leave has high costs for employers and societies and is a putative cause of social exclusion [1,2]. Low socioeconomic status (SES), indicated by income, education, and occupation is a strong predictor of sick leave [3-8]. There is a well-documented social gradient in health [9,10], but SES differences in sick leave is not merely a byproduct of the health gradient, because differences in health across SES strata can only account for a minor part of SES differences in sick leave [7,11,12]. Several possible pathways from SES to sick leave have been

described in previous literature. However, the results of some studies indicate that the association can be confounded, i.e., that other factors influence both SES and sick leave.

## How SES may affect sick leave

There are several mechanism by which SES may affect sick leave. Work attendance is influenced by both attendance ability (e.g. health) and motivation (e.g. job satisfaction, economic necessity) [13], and low SES may impair both. If low SES impairs health, it decreases the ability to attend work. Previous studies have found that low SES can affect physiological outcomes related to threat responses, such as systolic blood pressure [14,15]. In addition, low SES is associated with risky health

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behaviors [16] and harsher work environments. It is possible that SES affect these factors, and thereby ultimately sick leave. In line with this, work environment has been found to explain 20-60% of the SES differences in sick leave in the general population and samples of middle aged workers [4,6,8,17]. Harsh work conditions could also affect attendance ability because physically demanding jobs may not be adaptable to health impairments, while individuals with high SES jobs, typically in offices, are more often able to attend their jobs with similar impairments [18]. Low SES jobs are typically less rewarding, and this may influence attendance motivation and thereby sick leave. Such jobs often require high effort, and effort-reward imbalances have been found to predict sick leave [19,20]. Uncomfortable conditions could also affect attendance motivation, while high SES jobs are likely to elicit stronger internal motivation.

#### **Possible confounding of the association between SES and sick leave**

Results from previous studies indicate that the association between SES and sick leave can be confounded. In observational studies, it is usually not possible to distinguish the effects of SES on sick leave from the effects of factors that influenced SES. Educational attainment, income and sick leave are all affected by genetic factors as well as environmental factors shared by family members [21-26]. It is thus possible that some of the same genetic and/or environmental familial factors underlie both SES and sick leave. Twin data can be useful in determining whether an association is likely to reflect a causal relationship, because it is possible to adjust for unobserved familial confounders [27]. By comparing sick leave among twins reared together, but discordant on SES, it is possible to observe the association between SES and sick leave adjusted for genetic and environmental factors associated with the family [27]. If the association between SES and sick leave is smaller within discordant twin pairs than it is in the population generally, confounding by familial factors is indicated. Associations remaining after adjusting for familial factors are therefore likely to lie closer to causal effects [28].

The SES differences in health are commonly explained by a combination of SES causing health differences [18,29,30] and selection into SES on factors related to health ("indirect selection") [31,32]. If common factors, such as genetic or environmental familial factors, influence both health and SES, the association will be confounded. Previous studies have found the association between SES and several health measures to be confounded by familial factors [33,34]. Similarly, if factors influencing SES also affect sick leave, there will be spurious associations between SES and sick leave. Personality [35], self-control [36] and general ability [37] could

represent background risk factors confounding the association between SES and sick leave. There can also be selection into jobs with hard working conditions. For example, one study found confounding by familial factors in the association between physical work characteristics and later disability pensioning granted for low back pain disorders [38], although such confounding was not seen in the relationship between psychosocial work characteristics and disability pensioning granted for low back pain [39] or mental [40] disorders. Importantly, one twin study observed the association between education, an important SES indicator, and disability pensioning, a phenomenon strongly related to sick leave, to be confounded by familial factors [41]. It is therefore possible that also the association between SES and sick leave is confounded.

#### **Aims**

Educational attainment and income are related, but not interchangeable, indicators of SES [42]. This study utilizes a population sample of employed young adult twins and aims to (i) estimate the degree to which education and income are prospectively related to sick leave granted for mental and somatic disorders and sick leave granted for any disorder, and (ii) investigate whether these associations remain when adjusting for confounding genetic and environmental factors associated with the family, that is, whether the associations are consistent with a causal explanation.

#### **Methods**

##### **Sample and design**

The sample for the current study originated from the Norwegian Institute of Public Health Twin Panel (NIPHTP). The twins were identified through the national Medical Birth Registry, established January 1, 1967. The participants were twins born between 1967 and 1979 who took part in a large questionnaire study in 1998. All individuals were followed from approximately 30 years of age (details described below) and until the end of 2008, giving a mean follow-up time 6.57 years. By using national identification numbers issued to all Norwegians at birth, NIPHTP was linked to registries containing data on sick leave benefits, taxable income and highest educational attainment for the years 1998 to 2008.

Table 1 shows a summary of the construction of the sample and the length of follow-up by birth year. In brief, 12,700 twins were invited to the questionnaire study and 8,045 (63.3%) responded after one reminder. Of these, 7,710 were linked to sick leave data, while 335 twins withdrew from the study. In addition, 12 twins were excluded due to lack of data on zygosity, while 97 were excluded because they had emigrated. Of the

**Table 1 Construction of the sample and follow-up time by birth year**

Birth year	Chronological time											N linked	N employed
	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08		
1967	+	+	+	+	+	+	+	+	+	+	+	697	565
1968	+	+	+	+	+	+	+	+	+	+	+	720	548
1969		+	+	+	+	+	+	+	+	+	+	726	580
1970			+	+	+	+	+	+	+	+	+	657	504
1971				+	+	+	+	+	+	+	+	639	512
1972					+	+	+	+	+	+	+	601	475
1973						+	+	+	+	+	+	622	481
1974							+	+	+	+	+	558	439
1975								+	+	+	+	541	423
1976									+	+	+	532	406
1977										+	+	448	350
1978											+	529	434
1979											+	440	350
<b>Total</b>	Mean follow up time = 6.57 years											7710	6103

The number of individuals linked to registry and the number of individuals sufficiently employed to be followed. Individuals are followed in the years indicated by '+'.

remaining twins, 1,498 were not sufficiently employed at baseline and were excluded. Some of these were dead or already on disability pensioning, on long-term sick leave, or were still full-time students. Among the final sample of 6,103 twins (54.2% female), there were 2,024 complete pairs (384 monozygotic (MZ) male, 290 dizygotic (DZ) male, 453 MZ female, 332 DZ female, and 565 opposite sex twin pairs) and 2,055 single twins.

Zygoty classification was initially based on questionnaire data using discriminant analyses. Blood samples were obtained for a subsample of 676 like-sexed pairs, for whom zygoty was determined using 24 microsatellite markers. The results indicated a 97.5% correct original classification from questionnaire alone [43]. After correcting the originally misclassified pairs with DNA-based zygoty information, correct classification was estimated to be 98.0%.

### Ethics

Consent was granted via the return of a completed questionnaire or specific consent form. The Regional Committees for Medical and Health Research Ethics approved of the study and the linkage with registry data from Statistics Norway.

### Measures

#### Education attainment

Data on the highest completed education were available annually from 1998 to 2008 from the Norwegian Educational Database administered by Statistics Norway. A large part of the sample was in their 20s during this period, which is the time most people complete their

education and establish their workforce connection. We therefore decided to use educational attainment at age 30. In order to avoid excluding twins born in 1967 and 1979, for which educational data at age 30 were not available, educational attainment at age 31 (in 1998) and 29 (in 2008) was used. All individuals were followed from this age, rather than the date each individual became employed. This was done in order to avoid that people with low education should be systematically younger than those with high education. Also, this ensured that all co-twins were followed for the same length of time.

Educational attainment was registered with eight levels, ranging from no education to PhD or equivalent, according to the Norwegian Standard Classification of Education [44]. All included individuals had at least compulsory education, eliminating the lower end-point. PhDs ( $n = 31$ , 0.5%) were merged with master's degrees, resulting in six educational levels.

#### Income

Annual information on income was registered in the Income Registry at Statistics Norway. Several definitions of income were available. For the current study we applied the variable "work related income". As with educational attainment, we chose to use income the year the subjects turned 30 years old, or 29 or 31 if they were born in 1979 or 1967, respectively. Between 1998 and 2008 nominal incomes in Norway increased almost 60% [45]. Data on income were therefore adjusted in accordance with the average pay rise, to reflect 2008 equivalent income. Income was truncated at the 98th percentile.

### Employment and sick leave

We obtained a longitudinal dataset, including detailed information on sick leave from 1998 to 2008 from The Historical-Event Database. Sick leaves exceeding 16 days are covered by the mandatory Norwegian Insurance Scheme for a duration of up to 52 weeks. Thus, the minimal sick leave period recorded in this study was 16 days. For each day from January 1, 1998 to December 31, 2008, we had information on whether each participant was registered as employed and at sick leave. Diagnosis set by physicians when sick leaves were granted were also available, coded according to the International Classification of Primary Care [46]. All individuals were followed from January 1 the year they turned 30 (or 29 or 31 if they were born in 1979 or 1967) and until the end of the observational period (December 31, 2008). This resulted in an average follow-up time of 6.57 years. Three sick leave variables were constructed: Sick leave granted for mental disorders (all diagnoses in the P-chapter), sick leave granted for somatic disorders (diagnoses in all other chapters), and sick leave granted for any disorder, which includes sick leaves with missing diagnosis. In order to account for the multiple sick leaves, sick leaves of different duration, and each individual's level of employment, the variables for sick leave in each category were defined as a ratio (0–100%) of days lost to sick leave to the number of potential working days. Sick leave was only defined for individuals who had been employed and not at sick leave for at least 183 days during the first year they were followed. This criterion excluded individuals who already were on long lasting sick leave or rehabilitation, disabled individuals, full-time students, and other individuals with low labor-force participation.

### Statistical analyses

In accordance with the first aim, to estimate the associations between educational attainment, income and later sick leave, we ran linear regression analyses with random effects (Stata command *xtreg* option *re*), adjusting standard errors for dependency within pairs [27]. First, we estimated crude associations between sick leave and either education or income. Second, we adjusted these associations for sex and birth year. Third, we entered education, income and sick leave into the linear regression models simultaneously.

Our second aim was to investigate confounding by familial factors, that is, whether SES and sick leave were associated within twin pairs. We addressed this aim by estimating fixed effects (Stata command *xtreg* option *fe*) [47] within twin pairs, thereby adjusting for unobserved familial factors. MZ twins are genetically identical, whereas DZ twins share on average 50% of their genes out of those that vary in the population. In addition,

twins who grow up together are matched on shared environmental factors, that is, environmental factors that make the twins more similar to each other, such as neighborhood, school, or dietary factors during pregnancy, but differ on non-shared environmental factors, that is, environmental factors that contribute to twin differences, such as lifestyle choices or individual experiences. For MZ twins, all effects of genes and shared environment are controlled for, while for DZ twins, effects of shared environment and 50% of genetic effects are controlled for. If there are no confounders in the environment unique to each twin, association within MZ twin pairs are estimates of causal effects [48,49]. Because an association is a prerequisite for causation, lack of association within MZ twin pairs is inconsistent with causal effects [48,49]. On the other hand, reduced associations would suggest confounding by familial factors, either genetic, environmental or both. If the associations are more strongly reduced among MZ twins pairs than among DZ twin pairs, confounding by genetic factors is indicated [28]. Only complete pairs were included in the within twin-pair analyses.

Interaction effects between sex and education, sex and income, birth year and education, and birth year and income were tested in analyses at the individual level and within twin pairs. All the analyses were repeated for each of the three sick leave categories: Sick leave granted for mental disorders, sick leave granted for somatic disorders, and sick leave granted for any disorder. The outcome variables were kept to their original scale, so that a 1.0 increase on a sick leave variable indicated a 1.0 percentage point increase in sick days to planned work days. Because small proportions of sick leave are more common than large, the sick leave variables were positively skewed. Bootstrapping with 1,000 repetitions was run to provide unbiased standard errors and confidence intervals. All analyses were also repeated with Poisson regression, and no differences of significance were found.

### Software

The analyses were run in R 3.1.1 and Stata 12.1.

## Results

### Descriptive results

Table 2 shows the characteristics of the sample, as well as the proportion of workdays that were lost to sick leave granted for any disorder, somatic disorders, and mental disorders. Overall, 4.88% of workdays were lost to sick leave, of which 3.48% of workdays were lost to sick leave granted for somatic disorders and 0.93% to sick leave granted for mental disorders. The remaining sick leaves (0.47% of working days) had unknown diagnosis or were registered ambiguously in the registries. Sick leave was more common among women than

**Table 2 Characteristics of the sample and proportion of workdays lost to sick leave (SL)**

	N	SL any		SL somatic		SL mental	
		Mean	(SD)	Mean	(SD)	Mean	(SD)
<b>Gender</b>							
Male	2794	2.35	(6.24)	1.67	(5.06)	0.51	(3.00)
Female	3309	7.01	(9.96)	5.02	(8.14)	1.28	(4.51)
<b>Year of birth (mean = 1972.43, SD = 3.71)</b>							
1967-1970	2233	5.11	(8.36)	3.37	(6.22)	1.09	(4.03)
1971-1975	2330	5.07	(8.57)	3.77	(7.12)	0.93	(3.76)
1976-1979	1540	4.25	(9.59)	3.22	(8.18)	0.70	(3.95)
<b>Educational attainment (mean = 3.96, SD = 1.40)</b>							
1 Lower secondary	180	8.46	(12.83)	5.18	(8.89)	2.23	(6.96)
2 Upper secondary, basic	748	7.34	(10.06)	5.24	(8.69)	1.61	(4.68)
3 Upper secondary, final year	1987	5.23	(9.21)	3.90	(7.54)	0.91	(4.00)
4 Post-secondary non-tertiary	220	3.77	(7.70)	2.88	(6.56)	0.58	(3.52)
5 Undergraduate studies	2171	4.41	(8.09)	3.08	(6.50)	0.84	(3.50)
6 Master's degree or higher	797	2.46	(6.01)	1.69	(4.62)	0.37	(2.81)
<b>Income 2008 equivalent (mean = 376709 NOK, SD = 151151)</b>							
0 – 99,999 NOK	201	4.86	(10.37)	3.29	(8.53)	1.29	(5.38)
100,000 – 199,999 NOK	485	5.43	(9.20)	3.82	(7.87)	1.33	(4.41)
200,000 – 299,999 NOK	998	7.38	(10.60)	5.21	(8.35)	1.47	(5.15)
300,000 – 399,999 NOK	2026	5.69	(9.17)	4.14	(7.51)	1.01	(4.08)
400,000 – 499,999 NOK	1318	3.93	(7.86)	2.78	(6.38)	0.75	(3.34)
500,000 – 599,999 NOK	581	2.49	(5.56)	1.86	(4.71)	0.30	(1.77)
600,000 – 699,999 NOK	261	1.27	(3.69)	0.68	(1.81)	0.21	(1.25)
Above 700,000 NOK	233	1.38	(3.74)	1.07	(3.49)	0.16	(0.87)
<b>Total</b>	<b>6103</b>	<b>4.88</b>	<b>(8.77)</b>	<b>3.48</b>	<b>(7.10)</b>	<b>0.93</b>	<b>(3.91)</b>

SL granted for somatic disorders, mental disorders, and any disorder in percent. Average follow-up time is 6.57 years.

Note: The mean income corresponds to approximately €45000 or \$60000; 100000 NOK (Norwegian kroner) equals approximately €12000 or \$16000.

among men, and more common among individuals with low education and income. For example, more than three times as many workdays were lost to sick leave among those in the lowest educational category compared to those in the highest.

The mean difference between co-twins in educational attainment among the 2,024 complete twin pairs was 0.83 levels (SD = 0.97), which was higher among DZ twins (mean = 0.99, SD = 1.01) than among MZ twins (mean = 0.62, SD = 0.86). Among 837 MZ pairs, 498 had the same educational level, while 339 were discordant on education with on average 1.52 educational levels. Among 1187 DZ pairs, 485 were concordant on education, while 702 were discordant with an average of 1.67 educational levels. The mean difference in income within twin pairs was 135889 Norwegian kroner (NOK; 1 NOK ≈ €0.12 ≈ \$0.16) (SD = 123,179, n = 2024), which was lower among MZs (mean = 109021, SD = 105990, n = 837) than DZs (mean = 154834, SD = 130743, n = 1,187). The correlation between income and educational

attainment was 0.26 (95% C.I. 0.24 – 0.29, p <0.001) among all individuals. The mean difference in sick leave was 5.88 percentage points (SD = 8.82, n = 2024), and somewhat lower among MZ (mean = 5.09, SD = 7.97, n = 837) than DZ (mean = 6.44, SD = 9.34, n = 1187) twins.

### Regression analyses

Table 3 shows the estimates of the associations between educational attainment and income and sick leave. In the crude analyses (left column), income and education were associated with reduced sick leave granted for both mental and somatic disorders and a reduced sum of sick leave. Adjusted for sex and birth year (middle column), the associations between education and sick leave remained approximately the same, whereas the associations between income and sick leave became less pronounced. In the fully adjusted analyses (right column), where the effects of income and education are analyzed jointly, higher education was associated with reduced sick leave in all the categories, while higher

**Table 3 Associations between education, income, and sick leave (SL)**

		Crude		Adjusted <sup>a</sup>		Fully adjusted <sup>b</sup>	
		b	(95% C.I.)	b	(95% C.I.)	b	(95% C.I.)
SL somatic	Education	<b>-0.67</b>	<b>(-0.79, -0.54)</b>	<b>-0.69</b>	<b>(-0.82, 0.57)</b>	<b>-0.68</b>	<b>(-0.80, -0.55)</b>
	Income	<b>-0.64</b>	<b>(-0.74, -0.53)</b>	<b>-0.24</b>	<b>(-0.35, -0.13)</b>	-0.05	(-0.15, 0.06)
SL mental	Education	<b>-0.23</b>	<b>(-0.31, -0.15)</b>	<b>-0.22</b>	<b>(-0.30, -0.14)</b>	<b>-0.19</b>	<b>(-0.27, -0.10)</b>
	Income	<b>-0.24</b>	<b>(-0.30, -0.18)</b>	<b>-0.17</b>	<b>(-0.24, -0.11)</b>	<b>-0.12</b>	<b>(-0.19, -0.05)</b>
SL any	Education	<b>-0.92</b>	<b>(-1.08, -0.76)</b>	<b>-0.92</b>	<b>(-1.08, -0.75)</b>	<b>-0.88</b>	<b>(-1.04, -0.72)</b>
	Income	<b>-0.91</b>	<b>(-1.04, -0.78)</b>	<b>-0.36</b>	<b>(-0.50, -0.23)</b>	-0.12	(-0.25, 0.02)
N		6103		6103		6103	

SL granted for somatic, mental, and any disorder. Increase or reduction in sick leave of percentage points per unit increase in education or income. Notes: Bold values signify  $p < 0.05$ ; <sup>a</sup>Adjusted for sex and birth year; <sup>b</sup>Income and education analyzed jointly, adjusted for sex and birth year.

income was only significantly associated with reduced sick leave granted for mental disorders. For each increment in educational level, the level of sick leave granted for somatic disorders decreased on average with 0.68 percentage points ( $b = -0.68$ , 95% CI  $-0.80, -0.55$ ), sick leave granted for mental disorders decreased with 0.19 percentage points ( $b = -0.19$ , 95% CI  $-0.27, -0.10$ ), and sick leave in total decreased with 0.88 percentage points ( $b = -0.88$ , 95% CI  $-1.04, -0.72$ ).

Table 4 shows the within twin pair associations between sick leave and the predictors. Among DZ twins (left column), higher educational was associated with reduced sick leave granted for somatic disorders ( $b = -0.38$ , 95% CI  $-0.71, -0.05$ ) and with reduced sick leave granted for any disorder ( $b = -0.56$ , 95% CI  $-0.94, -0.19$ ). Education was not associated with sick leave granted for mental disorders ( $b = -0.06$ , 95% CI  $-0.25, 0.14$ ). Income was not significantly associated with any of the sick leave variables within DZ twin pairs. Combining MZ and DZ pairs gives higher statistical power, but lower control for confounding familial factors than analyses of only MZ pairs. In these analyses (middle column), the only significant association was between higher education and reduced sick leave granted for any disorder ( $b = -0.35$ , 95% CI  $-0.68, -0.03$ ). Within MZ twin pairs (right column), education ( $b = 0.19$ , 95% CI  $-0.37, 0.75$ ) and income

( $b = 0.30$ , 95% CI  $-0.07, 0.66$ ) was not significantly associated with sick leave granted for any disorder, or with the other sick leave variables. For sick leave granted for somatic or any disorder all estimates pointed in the opposite direction, that is, twins with higher SES tended to have more sick leave.

A graphical representation of the familial confounding is shown in Figure 1. The associations are reduced when moving from no correction for familial confounding, to partial correction in DZ pairs and complete correction for genetics and shared environment in MZ pairs. As can be seen, the effect of education within MZ twin pairs is clearly reduced compared to the individual-level analyses. The association with income was not significant in any of these analyses.

Interactions between sex and education, sex and income, birth year and education, and birth year and income were tested in all models. Out of 60 interaction tests, none were statistically significant at the  $\alpha = 0.01$  level.

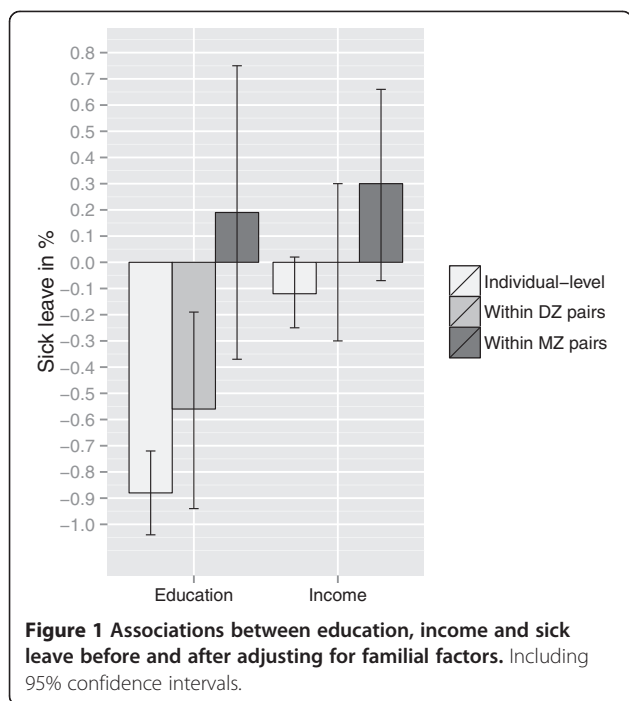
## Discussion

The most important findings of the present study were that education and income were strongly and prospectively associated with sick leave among 30 year old persons in paid work, but that these associations appeared to be confounded by familial factors and therefore are

**Table 4 Within-twin pair associations between education, income, and sick leave (SL)**

		Dizygotic pairs		All twin pairs		Monozygotic pairs	
		b	(95% C.I.)	b	(95% C.I.)	b	(95% C.I.)
SL somatic	Education	<b>-0.38</b>	<b>(-0.71, -0.05)</b>	-0.21	(-0.48, 0.05)	0.21	(-0.21, 0.63)
	Income	0.05	(-0.22, 0.31)	0.09	(-0.11, 0.30)	0.19	(-0.10, 0.48)
SL mental	Education	-0.06	(-0.25, 0.14)	-0.08	(-0.24, 0.08)	-0.14	(-0.43, 0.15)
	Income	-0.09	(-0.25, 0.07)	-0.06	(-0.18, 0.05)	-0.02	(-0.18, 0.14)
SL any	Education	<b>-0.56</b>	<b>(-0.94, -0.19)</b>	<b>-0.35</b>	<b>(-0.68, -0.03)</b>	0.19	(-0.37, 0.75)
	Income	0.00	(-0.30, 0.30)	0.09	(-0.15, 0.33)	0.30	(-0.07, 0.66)
N pairs		1187		2024		837	

SL granted for somatic, mental, and any disorder. Increase or reduction of sick leave in percentage points per unit increase in education or income. Notes: Bold values signify  $p < 0.05$ ; Income and education were analyzed jointly, and results adjusted for sex and birth year.



probably not causal. We also found that low educational attainment was more predictive of sick leave than was low income in this age group.

The finding that low SES was associated with higher levels of sick leave replicates previous studies (e.g. [3,7]). We found SES differences in sick leave granted for both mental and somatic diagnoses, as well as with sick leave granted for any disorder. Education was more strongly related to sick leave than was income. A possible explanation is that education better reflects social status in young adulthood than income does, because returns to education are relatively low in Norway [50] and other egalitarian societies [47]. In addition, those with long education will have less work experience, which may be relevant for income in young adulthood. Nevertheless, income did have a significant association with sick leave granted for mental disorders independent of the effect of education.

Adjusting for factors shared by co-twins reduced the associations between SES and sick leave. Within MZ twin pairs, SES was not statistically significantly related to any of the sick leave variables. Therefore, the association between SES and sick leave is at least strongly, and possibly fully, confounded by familial factors. Several indices substantiate this: When the data were stratified on zygosity, the results in both the MZ sample and the DZ sample indicated familial confounding. The associations within DZ pairs, where the adjustment of genetic factors is partial, lay between the individual-level estimates and the associations within MZ pairs, where adjustment of familial factors is complete. In addition, for sick leave granted for any disorder and for sick leave granted for

somatic disorders, the whole association with education disappeared in the within MZ pair analyses, and the estimates pointed non-significantly in the opposite direction, probably by chance. Non-significant findings cannot be taken as evidence that causal effects between SES and sick leave do not exist. However, considering the sizes of the confidence intervals, possible causal effects are clearly smaller than the crude associations between SES and sick leave.

As far as we are aware, no previous study has used twins to investigate whether the association between SES and sick leave is confounded or whether it is consistent with causality. Several causal mechanisms for the SES differences in sick leave have been described. Nevertheless, a few previous studies have found the associations between SES and constructs related to sick leave, such as health [33,34] or disability pensioning [41], to be confounded by familial factors. If it is true that low SES is not causally related to sick leave among young adults (in either direction), there must be a set of factors that influence both SES and sick leave. One may speculate that involved factors could be related to personality traits such as neuroticism or conscientiousness [51-53], general ability [37], or related to self-control [36]. The familial confounding is not likely to only consist of risk factors for specific disorders, because health differences do not explain all SES differences in sick leave [7].

If social class background rather than personally achieved education and income affected sick leave, one should expect to find similar results for MZ and DZ twins. This was not the case. The associations between sick leave and SES were stronger within DZs, who differ with respect to genetic factors, than within MZ pairs, who do not. This indicates that the familial factors confounding the associations between SES and sick leave are at least partly genetic.

The current findings concern education and income. Other indicators of SES, such as social capital or occupation, can have other types of relationships with sick leave. Some individuals hold jobs where they cannot fully utilize their education, whereas other individuals with low educational level achieve high-status positions. It is possible that twins who are discordant on education or income are more similar on occupational status than are unrelated individuals with similar difference in education and income.

Further, and importantly, if health differences between SES groups are due to lifestyle, diet, substance abuse, health literacy or wear and tear injuries, the effects of these are likely to accumulate over time. The effects of SES on sick leave may therefore be stronger among older individuals. Consistent with this line of reasoning, disability pensioning seems to be less heritable in older [54,55] compared to younger samples [24]. In addition, disability pensioning has been found to be associated with education within middle aged twin pairs [56].

## Limitations

This study has several strengths, such as prospective registry data on exposures and outcomes in a genetically informative population based sample of employed young adults. Nonetheless, some limitations must be mentioned. First, the power to detect statistically significant effects within MZ pairs was moderate. Although the association between education and sick leave was clearly reduced in this group, the lack of significance (in either direction) can be a type II error. Second, not all individuals have reached their highest education at age 30. However, only individuals who were working at baseline were included in the study, thus excluding for example full-time students, and individuals who had not entered work-life for other reasons, such as health. Third, co-twin control studies, like the present, cannot resolve issues of causality without reservations [48,49]. Nevertheless, they can adjust for unmeasured factors related to the family and thereby come a step closer to estimating causal effects than most other methods. Co-twin control studies are especially vulnerable to measurement error. The use of registry-based variables for both exposure and outcome was therefore especially important in this study. Fourth, in the current study we only considered long term sick leave (lasting for at least 16 days). Thus we do not know whether we would find exactly the same results for short-term sick leave. Finally, the results are best generalizable to Nordic countries and European countries with similar welfare schemes.

## Conclusions

Educational attainment, and, to a lesser extent, income, were associated with a prospective risk of sick leave granted for mental, somatic or any disorders among employed young adults. There were no associations within MZ twin pairs, indicating that confounding by factors that are common to co-twins appears to account for most of the SES differences in sick leave among young adults. Education and income are therefore not likely to strongly affect sick leave in young adulthood.

## Abbreviations

SES: Socioeconomic status; MZ: Monozygotic; DZ: Dizygotic; SL: Sick leave.

## Competing interests

The authors declare that they have no competing interests.

## Authors' contributions

FAT was primarily responsible for data analysis and drafting the manuscript. EY contributed considerably to data analysis and interpretation. NC contributed to data acquisition and transforming the governmental registry data into analyzable variables. KT contributed to data acquisition, analyses and interpretation. ER contributed to analyses and interpretation. RØ contributed considerably to interpretation of the results. GPK was responsible for data acquisition (linking and approval). KSK contributed considerably to interpretation of the results. TRK planned the project and supervised all the tasks described above. All authors read and approved the final manuscript.

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