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Suicide during University Studies

A national cohort of 5 million individuals over a period of 18 years

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ABSTRACT

Objectives: To investigate suicide risk during university studies by comparing to non-students, taking educational attainment into account. We also assessed the risks of unnatural death and all-cause death during university studies.

Design: Open cohort study of all residents aged 18-39 and living in Sweden at any time between January 1, 1993 and December 31, 2011.

Setting: We linked register data from nationwide registers for the years 1993-2011 and identified for three different time periods (1993-1999, 2000-2005 and 2006-2011) person years in ongoing university studies. We retrieved data from the Cause of Death Register on suicide (ICD-9: E950–E959, ICD-10: X60–X84) or death with undetermined intent (ICD-9: E980-E989, ICD-10: Y10-Y34), unnatural death (ICD-9: E800-E999 and ICD-10: V01-Y99) and all-cause death. Poisson regression was applied to calculate the incidence rate ratio (IRR) with 95% confidence intervals (CI), controlling for time period and for age.

Participants: 5,039,419 eligible individuals were identified during the studied time period, of which 51% were men and 49% were women.

Main outcome measures: Incidence of suicide, unnatural death and all-cause death during ongoing university studies.

Results: 7,316 deaths due to suicide were identified, of which 541 were registered during ongoing university studies. The risk for suicide was twofold during ongoing university studies compared to when having attained university, IRR 2.37 (95% CI: 2.07 to 2.72) in men and IRR 2.15 (95% CI: 1.77 to 2.61) in women.

Conclusions: Having ongoing university studies was associated with a higher risk of suicide compared to having attained university level education. This finding highlights the

importance of a deeper understanding of suicidal behaviour during higher education. Further studies should assess risk factors for suicide and suicidal behaviour in this group.

Strengths:

- The first study of university student mortality in a large national cohort.
- The high quality and validity of Swedish national registers with complete nationwide coverage of exposure and a long follow-up time.
- The first study taking educational attainment into account when estimating suicide risk.

Limitations:

- Generalisability of our results may be affected by differences in educational standards between countries.
- We have not examined possible explanations for the increased suicide risk in university students.

INTRODUCTION

Suicide is one of the leading causes of death for young people globally, where men are up to three times more likely than women to commit suicide (1). In several countries in the world an increasing proportion of young adults decide to pursue university studies (2, 3). Almost 40% of young adults in high-income countries today are expected to finalise university level education during their lifetime (2). The university period carries responsibilities and a pressure to succeed which may increase mental distress, depression or excess alcohol use (4-7). In addition, university students have been found to experience low life satisfaction and to be more depressed than a non-student population of a similar age (4, 6, 8-11). As a result, some students may succumb to suicidal ideation and a risk of committing suicide (12-15).

Low educational level is associated with a higher risk of suicide as well as for all-cause death

(16-24). Previous studies of suicide risk in university students have predominantly compared students to the general population, without taking education level into account, finding similar or lower suicide rates for university students when compared to age-matched populations (25-30). By not considering differences in educational attainment, they may however have underestimated the risk of suicide in university students.

Our aim was to investigate suicide rate and estimate the risk of suicide during university studies by making a comparison to non-students, taking educational attainment into account. It was hypothesised that the risk of suicide would be higher during university studies compared to after having attained university education.

METHODS

We selected all residents aged 18-39 and living in Sweden at any time during 1993-2011 (N= 5 039 419). The open cohort, to which newly turned 18 year-olds entered each year was followed until December 31, 2011. Subjects were censored at emigration, age 40 and end of follow-up or death. Information on eligible residents, country of birth, and date of emigration was retrieved from the Register of the Total Population (Statistics Sweden), which is continuously updated with all births, deaths, immigration, emigration and migration within Sweden of all residents (31).

Highest attained level of education was retrieved from the Longitudinal Integration Database for Health Insurance and Labour Market studies (LISA, Statistics Sweden). Data on current university studies was retrieved from the Administrative data for University and Higher education (Statistics Sweden).

Dates and causes of death were retrieved from the Cause of Death Register (National Board of Health and Welfare), which contains all deaths of residents in Sweden since 1961 (32). The

unique personal identification number assigned to all residents in Sweden was used for accurate linkage of information between the registers (33).

Classification of exposure and person-time at risk

We defined ongoing university studies as having registered on a course at university during the current semester. Since registration is not recorded instantly at the start of a semester, we defined the spring semester as starting from March 1 and continuing to September 31, including the summer months (7 months' person-time) and the autumn semester lasting from October 1 to February 28 (5 months' person-time) by each year during the follow-up.

For those currently not registered for a subject at university we identified 3 different categories of exposure according to highest attained level of education: secondary education or less (9 years of schooling is compulsory in Sweden), upper secondary education (12 years of schooling) and attained university education. In order to be classified as having attained university education a person always needed to have finalized a minimum of one semester at university. Person years for attained university studies were distributed as follows: 20-36% of less than 2 years of university studies and 60-77% of over 2 years of university studies. Having attained less than 2 years of university studies was more common between 1993 and 2000 than in later years. 1-3% of person years consisted of postgraduate studies.

Time at risk of having attained university education was chosen as reference. Period was divided into three categories (1993-1999, 2000-2005 and 2006-2011). For all subjects, person-time at risk was calculated and allocated to the corresponding exposure category. Subjects could move between exposure categories. Figure 1 depicts 6 presumptive subjects and their allocated person-time at risk.

Outcomes

The main outcome was suicide and it was defined as having an underlying cause of death, in the Cause of Death Register, coded according to the International Statistical Classification of Diseases and Related Health Problems (ICD, versions 9 and 10) as suicide (ICD-9: E950–E959, ICD-10: X60–X84) or as death with undetermined intent (ICD-9: E980-E989, ICD-10: Y10-Y34). The two other outcomes were unnatural death, defined as having an underlying cause of death (ICD-9: E800-E999 and ICD-10: V01-Y99 (including suicide as above)) and all-cause death (34).

Statistical analysis

Poisson regression analyses were used to evaluate the association between educational status and suicide or other death by calculating the incidence rate ratio (IRR) with a 95% confidence interval (CI). We assessed person-time at risk by adding together the time the subjects were alive and living in Sweden under each of the exposure conditions. Since subjects could move between exposure categories, person-time at risk was allocated to the current exposure category without taking any lag effects of exposure into account. Three regression models stratified by sex, were analysed; Model I crude model, Model II adjusted for age in three categories (18-24, 25-29, 30-39 years), and Model III (presented in text only), additionally adjusted for period (1993-1999, 2000-2005, 2006-2011). Two sensitivity analyses were conducted. In the first, we excluded death with undetermined intent, using only certain suicides for calculation. The other sensitivity analysis was conducted to control for country of birth, excluding those born outside of Scandinavia.

SAS Genmod procedure was used to calculate IRRs and 95% confidence intervals (CIs) for suicide, with attained university studies as the reference category. SAS v. 9.4 (SAS Institute Inc., Cary, NC, USA) was used.

RESULTS

The open cohort included 5 039 419 individuals, of whom 2 569 266 (51%) were men and 2 470 193 (49%) were women. We identified a total of 7 316 deaths due to suicide (Table 1), of which 541 were registered during ongoing university studies. Suicides constituted 63.4% of all unnatural deaths (N=11 533) and 29.7% of all all-cause deaths (N=24 672). During ongoing studies, suicides constituted 71.4% of the unnatural deaths (N=757) and 36.4% of the all-cause deaths (N=1 485).

Mortality rates for all studied outcomes were highest under the exposure of secondary or lower education and lowest for those who had attained university education. Suicide mortality rates during ongoing studies were 19.0/100 000 person years for men and 7.2/100 000 person years for women (Table 1).

Table 1. Mortality rate per 100,000 person years of all suicides and all-cause deaths with 95% confidence intervals (CI) by sex and highest attained education level, for individuals aged 18-39 during 1993-2011 in Sweden.

		Mortality					
		Suicide			All-cause death		
	Educational level	N	Rate	95%CI	N	Rate	95%CI
Men							
	Secondary or lower	1746	41.0	(39.1-42.9)	5 620	132.0	(128.6-135.5)
	Upper secondary	2766	22.3	(21.5-23.1)	8 761	70.6	(69.1-72.1)
	Ongoing university	358	19.0	(17.0-21.0)	907	48.2	(45.0-51.3)
	Att. university	539	10.4	(9.6-11.3)	1 813	35.1	(33.5-36.7)
Women							
	Education						
	Secondary or lower	610	17.3	(15.9-18.7)	2 122	60.1	(57.6-62.7)
	Upper secondary	858	7.8	(7.3-8.3)	3 560	32.5	(31.4-33.5)
	Ongoing university	183	7.2	(6.2-8.3)	578	22.8	(21.0-24.7)
	Att. university	256	4.3	(3.8-4.9)	1 311	22.2	(21.0-23.4)

N=number of deaths; Att.=attained

The proportion of person years in ongoing university studies was largest for 18-24 year olds and smallest for 30-39 year olds for both sexes (Table 2a and 2b). Inversely, the proportion of person years of attained university was largest for 30-39 year olds and smallest for 18-24 year olds. In the age group of 18-29 year olds a larger proportion of female suicides, 8.6-18%, than male suicides, 7.2-12.5%, were committed during ongoing university studies (Table 2a and 2b).

Table 2a. Numbers of suicide and distribution of person years for men by age, period and highest attained education level in Sweden.

		Men											
		1993-1999				2000-2005				2006-2011			
Age	Educational status	No. suic	% Suic	1000 Pyrs	% Pyrs	No. suic	% Suic	1000 Pyrs	% Pyrs	No. suic	% Suic	1000 Pyrs	% Pyrs
18-24	Secondary or lower	143	(39.0)	637	(25.6)	212	(51.2)	631	(29.3)	252	(46.5)	715	(28.6)
	Upper secondary	181	(49.3)	1375	(55.2)	165	(40.0)	1,093	(50.7)	212	(39.1)	1 295	(51.8)
	Ongoing university	42	(11.4)	343	(13.8)	37	(8.9)	346	(16.0)	68	(12.5)	380	(15.2)
	Attained university	1	(0.3)	135	(5.4)	6	(1.4)	87	(4.0)	10	(1.8)	113	(4.5)
25-29	Secondary or lower	131	(31.7)	284	(14.2)	107	(31.8)	181	(10.9)	170	(35.0)	218	(13.2)
	Upper secondary	221	(53.4)	1119	(56.2)	171	(50.9)	870	(52.4)	224	(46.1)	779	(47.1)
	Ongoing university	30	(7.2)	162	(8.2)	32	(9.5)	173	(10.4)	52	(10.7)	174	(10.5)
	Attained university	32	(7.7)	427	(21.4)	26	(7.7)	438	(26.4)	40	(8.2)	484	(29.2)
30-39	Secondary or lower	329	(30.0)	754	(19.0)	210	(24.4)	453	(12.1)	192	(21.8)	385	(10.9)
	Upper secondary	607	(55.1)	2 077	(52.4)	495	(57.6)	2 047	(54.4)	490	(55.6)	1 751	(49.6)
	Ongoing university	32	(2.9)	94	(2.4)	23	(2.7)	111	(2.9)	42	(4.8)	100	(2.8)
	Attained university	134	(12.2)	1039	(26.2)	132	(15.3)	1 150	(30.6)	158	(17.9)	1 296	(36.7)

Pyrs=person years; Suic=suicides

Table 2b. Numbers of suicide and distribution of person years for women by age, period and highest attained education level in Sweden.

		Women											
		1993-1999				2000-2005				2006-2011			
Age	Educational status	No. suic	%	1000 Pyrs	%	No. suic	%	1000 Pyrs	%	No. suic	%	1000 Pyrs	%
18-24	Secondary or lower	64	(45.0)	597	(24.4)	82	(59.0)	538	(26.2)	93	(47.0)	608	(25.5)
	Upper secondary	59	(41.5)	1272	(52.1)	44	(31.6)	951	(46.2)	74	(37.4)	1118	(47.0)
	Ongoing university	18	(12.7)	423	(17.3)	12	(8.6)	438	(21.3)	28	(14.1)	497	(20.9)
	Attained university	1	(0.7)	152	(6.2)	1	(7.2)	130	(6.3)	3	(1.5)	157	(6.6)
30-39	Secondary or lower	45	(34.6)	255	(13.0)	33	(27.0)	142	(8.9)	38	(27.1)	153	(9.7)
	Upper secondary	54	(41.5)	1066	(54.5)	56	(45.9)	708	(44.4)	57	(40.7)	583	(37.1)
	Ongoing university	14	(10.8)	169	(8.6)	22	(18.0)	210	(13.2)	21	(15.0)	218	(13.9)
	Attained university	17	(13.1)	466	(23.8)	11	(9.0)	534	(33.5)	24	(17.1)	618	(39.3)
	Secondary or lower	98	(26.3)	599	(15.4)	79	(24.7)	345	(9.5)	78	(22.7)	292	(8.6)
	Upper secondary	204	(54.8)	2043	(52.4)	162	(50.6)	1828	(50.5)	148	(43.0)	1,395	(40.9)
	Ongoing university	22	(5.9)	161	(4.1)	16	(5.0)	222	(6.1)	30	(8.7)	195	(5.7)
	Attained university	48	(12.9)	1099	(28.2)	63	(19.7)	1223	(33.8)	88	(25.6)	1532	(44.9)

Pyrs=person years; Suic=suicides

Table 3 presents IRRs for the association between educational status and suicide or all-cause death. The IRR, adjusted for age, indicated a higher risk during ongoing university studies compared to when having attained university studies, for men (IRR=2.37, 95% CI, 2.07-2.72) and for women (IRR=2.15, 95% CI, 1.77-2.61). The association was marginally stronger after adjustment for period. Sensitivity analyses, excluding verdicts of undetermined intent, did not markedly change the estimates and also revealed that the association was similar among those born within and outside of Sweden.

Table 3. Highest attained level of education and incidence rate ratio (IRR) of all cause of death, unnatural death and suicide with 95% confidence intervals (CI) by sex for ages 18-39, in 1993-2011, in Sweden. Attained university level education is the reference.

		Suicide		All-cause death	
		Crude	**Adjusted[1]**	**Crude**	**Adjusted[1]**
	Educational level				
Men	Secondary or lower	3.93 (3.57-4.33)	4.76 (4.31-5.25)	3.76 (3.57-3.97)	4.66 (4.41-4.91)
	Upper secondary	2.14 (1.95-2.34)	2.39 (2.18-2.62)	2.01 (1.91-2.12)	2.28 (2.17-2.40)
	Ongoing university	1.82 (1.60-2.08)	2.37 (2.07-2.72)	1.37 (1.27-1.49)	1.88 (1.73-2.04)
	Attained university	1	1	1	1
	Educational level				
Women	Secondary or lower	3.99 (3.45-4.62)	4.90 (4.22-5.69)	2.71 (2.53-2.90)	3.67 (3.42-3.94)
	Upper secondary	1.81 (1.57-2.08)	2.01 (1.75-2.32)	1.46 (1.37-1.56)	1.71 (1.61-1.83)
	Ongoing university	1.67 (1.38-2.02)	2.15 (1.77-2.61)	1.03 (0.93-1.13)	1.55 (1.40-1.71)
	Attained university	1	1	1	1

[1]=Adjusted for age (18-24), (25-29) and (30-39).

The IRR for all-cause mortality, adjusted for age, also indicated a higher risk during ongoing university studies compared to after having attained university studies. The result for men was IRR=1.88 (95% CI, 1.73-2.04) and for women IRR=1.55 (95% CI, 1.40-1.71).

For unnatural death the IRR indicated an approximately twofold higher risk during ongoing university studies compared to when having attained university studies for men (IRR=2.02, 95% CI, 1.80-2.27) and for women (IRR=1.96, 95% CI, 1.67-2.30) (not shown in tables).

DISCUSSION

In this national cohort study, having ongoing university studies was associated with a twofold risk of suicide compared to having attained university education. The risk was slightly higher for men than for women.

Our population cohort, using large national registers of high quality and validity with complete nationwide coverage of exposure (ongoing university studies and educational attainment) as well as outcome (suicide and other death) and long follow-up, is unprecedented in university student suicide research. This provides our study with high generalisability and considerable power.

Taking educational attainment into account when estimating risk is, to our knowledge, unique in studies of university student suicides. Results from previous studies may have been confounded due to differences in educational level. Low educational attainment is associated with a higher risk for both all-cause death and suicide (16-21). High educational attainment on the other hand is associated with a better overall health and a lower mortality (22). However, for people with a high educational level suicide risk appears to be greater relative to the risk of other causes of death than for people with low education (35).

In order to avoid underestimation of the number of suicides in our cohort, we included death with underdetermined intent (36), which is in line with several previous studies (37, 38). Retrospective analyses of deaths of undetermined intent suggest that these should be included in the definition of suicide (39). We conducted sensitivity analyses, excluding death by undetermined intent, to ensure that estimates of suicide risk did not substantially change.

The generalisability of our results may be affected by the fact that education in Sweden is tuition free and that all university students are granted general financial aid during ongoing studies. In contrast to many other countries, this allows for anyone with sufficient motivation, grades and previous educational attainment to enter higher education. However, since this is a longitudinal study of an entire national student population our results contribute with a higher representativeness than any previous study.

The university student suicide rates found in the current study are higher than those reported in American studies of college and university students (25-27). The suicide rate for ongoing studies in the present investigation was 19.0/100,000 person years for men, considerably higher than the suicide rate of 10.9/10,000 person years for men in a study of 645 university and college campuses (25). Similarily, the suicide rate for women was higher, 7.2/100,000 person years, compared to 3.1/100,000 person years (25). Another study of suicide rates at 12 university campuses found a rate of 10.0/100,000 person years for men and 4.5/100 000 person years for women (26). A comparison of U.S. university and college student suicide rates over four eras (1920-60, 1960-80, 1980-90, 1990-2004) found that the rate decreased over time from 13.4 in the first period to 6.5 in the latest period (27).

One explanation for the differences in suicide rates may be that the educational systems are different between Sweden and the U.S. Although exposure to the first university years in Sweden may be considered similar to U.S. college education, Swedish education, being tuition-free, may be considered more easily accessible. The higher suicide rates for Swedish

male students cannot be explained by Sweden having a higher national suicide rate than the United States (1). In 2012 the age-adjusted suicide rate for men was 16.2/100,000 in Sweden and 19.4/100,000 in the U.S (1). The suicide rate for women the same year was higher, 6.1/100,000, in Sweden compared to 5.2/100,000 in the United States (1). Possible further explanations to the differences in suicide rates may be that our study had full national coverage, giving a more accurate estimation and also that, in difference to the U.S. studies, the current study had no concern with possible underreporting of suicides from universities (26).

Although low educational level has repeatedly been linked to poorer health and an increased suicide as well as overall mortality risk (16-21), no other study compared suicide risk during ongoing university studies to the risk according to attained level of education. A study of Oxford university students found a slightly higher suicide rate than expected among 18-25 year olds in England and Wales (28). Yet, two other British studies showed no difference in suicide rates between students at high ranking Oxford University and Cambridge University and suicide rates in the general population of the same age (29, 30). By taking educational attainment into account, our study provides a more differentiated picture of student suicide risk than previous studies.

Because a considerable number of university students are older than 18-24 years we extended the age span of persons in the cohort up to 39 years. Most persons with ongoing university studies are between 18 and 24 years of age and thus this age span contributed more to the main exposure, whereas most that had attained university were 30-39 years-old and therefore contributed with more person years to the reference category. This may explain why our estimates changed considerably when adjusting for age. Further, students over 25 years of age have been found to have a significantly higher suicide risk than younger students (26).

It may be argued that those who have attained university education are a selected population that was never at risk of committing suicide during ongoing studies. Indeed, it has been suggested that suicide rates are higher for university or college dropouts (26). However, since our classification of attained university education in the present study was quite heterogeneous, encompassing anything from having completed one semester to having attained a degree in for example law or medicine, and individuals could move between exposure conditions, we think that such an objection is weakened.

The present study shows a higher suicide risk during ongoing university studies, but we have not investigated possible explanations to this finding, which are most likely multifactorial and complex. The university or college study environment presents demands and expectations of achievement that may cause considerable mental distress in some individuals (4-7). Depression, which is a risk factor for suicide, has been found to be more common among university students than in the general population (4, 5, 9). A study of suicide attempters admitted to a psychiatric hospital showed that the university student sample was younger than other patients, used less violent methods and were less likely to have a history of substance abuse (40). Future studies should investigate which specific risk factors, e.g. mental distress, performance-related anxiety, type of education and university, are associated with suicide risk in university students.

Conclusion

In conclusion, this national cohort study shows a twofold risk of suicide during ongoing university studies compared to when having attained university education. University students who commit suicide die from a preventable cause and despite being protected by known factors that decrease suicide risk such as having a high educational attainment. Our finding warrants attention from public health efforts and in student health care.

Contributors: MD had the original idea for the study and designed it together with RL and MV. The authors are grateful to Professor Bo Runeson for contribution in discussions of study design and results. MD and MV managed the dataset and Fredrik Mattson at FM Statistikkonsult has contributed with statistical analyses. CTL, MD, RL and MV interpreted results and co-wrote the paper. MD is guarantor.

Competing interests: All authors have completed the unified competing interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare no conflicts of interest with research granters and no financial relationships with commercial entities which may have interest in the submitted work.

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Data sharing: No additional data available.

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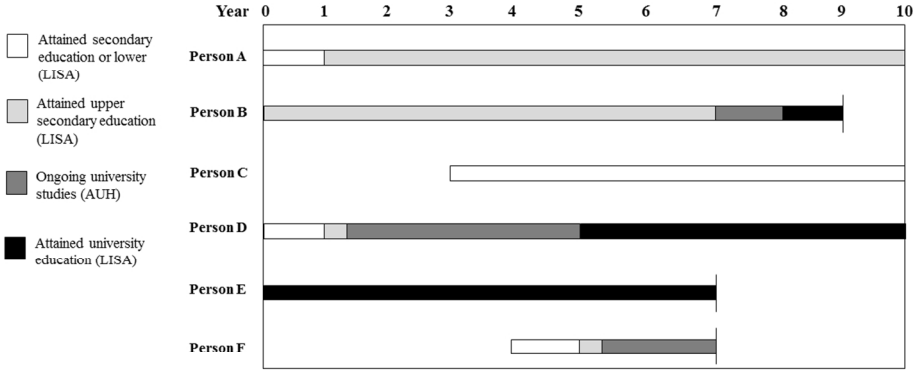

Figure 1. An illustration of how exposure was measured according to educational status. The figure shows an example of six fictional persons A-F and how the exposure educational status was defined and could change for the same individual during a period of 10 years. When not currently studying at university subjects returned to the exposure of highest attained education.
Person A) Is included year 0 at 18 years. Attains upper secondary education after 1 year. Does not begin university studies.
Person B) Is included year 0 at age 20. Has attained upper secondary education. Studies at university year 7-8. Dies year 9.
Person C) Is included year 3 when he reaches age 18. Has attained secondary education. Does not pursue further studies.
Person D) Is included year 0 at age 18. Has attained upper secondary education after 1 year. Starts at university in August but is registered for the first semester in October, thus for three months he has the exposure of attained 12 years. Studies at university for 3 years.
Person E) Is included year 0 at 33 years. Has attained university studies. Is censored year 7 due to having turned 40 years old.
Person F) Is included year 4 at 18 years, has attained upper secondary education after 1 year. Starts university year 5, is registered after 3 months during which she has the exposure attained 12 years, moves abroad year 7 and is censored.
LISA= Longitudinal Integration Database for Health Insurance and Labour Market studies;
AUH=Administrative data for University and Higher education

338x190mm (96 x 96 DPI)

Suicide during university studies
A national cohort of 5 million individuals over a period of 18 years

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Our comments
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	The term "cohort" is included in the title (**page 1**) as an indicator of the study design
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	An attempt to make an informative and balanced summary can be viewed on **page 2**
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	On **page 3-4** a scientific background and rationale for the study is reported
Objectives	3	State specific objectives, including any prespecified hypotheses	Specific objectives are stated on **page 4.**
Methods			
Study design	4	Present key elements of study design early in the paper	Key elements of the study design are presented on page **4.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Setting, locations, dates, exposure, follow-up and data collection are described on **pages 4-5**.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Participants and methods of follow-up are described on **pages 4-5.**
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Outcomes and exposures are defined on **pages 4-5**. Confounders are mentioned in the Discussion, **page 11**.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Assessment methods are stated on **pages 5-6.**
Bias	9	Describe any efforts to address potential sources of bias	In the Discussion, **page 11**.
Study size	10	Explain how the study size was arrived at	Study size is described on **page 4**.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	How categories were chosen is described on **page 5**.
Statistical methods	12	(*a*) Describe all statistical methods, including those	This is described on **page 6**.

		used to control for confounding	
		(*b*) Describe any methods used to examine subgroups and interactions	This is described on **page 6**.
		(*c*) Explain how missing data were addressed	Not applicable.
		(*d*) If applicable, explain how loss to follow-up was addressed	Not applicable.
		(*e*) Describe any sensitivity analyses	This is described on **page 6.**
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Number of participants is described on **pages 4 and 6**.
		(b) Give reasons for non-participation at each stage	Not applicable.
		(c) Consider use of a flow diagram	We decided that this was sufficiently described in text.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1.
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable.
		(c) Summarise follow-up time (eg. average and total amount)	Not applicable.
Outcome data	15*	Report numbers of outcome events or summary measures over time	Described on **pages 6-7**.
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 3.
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable.
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No absolute risks are reported.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Sensitivity analyses are reported on **page 7**.
Discussion			
Key results	18	Summarise key results with reference to study objectives	**Pages 14-15**.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	**Page 16 and 17.**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	**Pages 16-17**.
Generalisability	21	Discuss the generalisability (external validity) of the study results	**Page 14** (strength) and **page 15** (limitation).

Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	**Page 18**.

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Ongoing university studies and the risk of suicide
A nationwide population-based cohort study of 5 million individuals in Sweden over a period of 18 years

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Ongoing university studies and the risk of suicide

A nationwide population-based cohort study of 5 million individuals in Sweden over a period of 18 years

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ABSTRACT

Objectives: To investigate the risk of suicide, unnatural death and all-cause death in university students compared to non-students, taking previous educational attainment into account.

Design: Open cohort study of all residents aged 18-39 and living in Sweden at any time between 1 January, 1993 and 31 December, 2011.

Setting: We linked data from national registers and calculated person years during university studies for three time periods (1993-1999, 2000-2005 and 2006-2011). Time as non-student was calculated and categorised according to attained educational level. Incidence rate ratios (IRR) with 95% confidence intervals (CI) were calculated with Poisson regression models, controlling for age and period.

Participants: The cohort consisted of 5,039,419 individuals, 51% men and 49% women.

Main outcome measures: Incidence of suicide (ICD-9: E950–E959, ICD-10: X60–X84) or death with undetermined intent (ICD-9: E980-E989, ICD-10: Y10-Y34), unnatural death (ICD-9: E800-E999 and ICD-10: V01-Y99) and all-cause death.

Results: A total of 7 316 deaths due to suicide were identified, of which 541 were registered among university students. The risk of suicide was twofold during ongoing university studies compared to when having attained university education, IRR 2.37 (95% CI: 2.07 to 2.72) in men and IRR 2.15 (95% CI: 1.77 to 2.61) in women.

Conclusions: Having ongoing university studies was associated with a higher risk of suicide compared to having attained university level education. This finding highlights the importance of achieving a deeper understanding of suicidal behaviour during years at university. Further studies should assess risk factors for suicide and suicidal behaviour in this group.

Strengths:

- The first study on mortality among university students in a large nationwide cohort.
- The high quality and validity of Swedish national registers with complete nationwide coverage of exposure and a long follow-up time.
- The first study taking educational attainment into account when estimating suicide risk.

Limitations:

- Generalisability of our results may be affected by differences in educational standards between countries.
- We have not examined the possible predictors for an increased suicide risk in university students.

INTRODUCTION

Suicide is one of the leading causes of death in young people globally, where men are up to three times more likely than women to die by suicide (1). In several countries in the world an increasing proportion of young adults decide to pursue university studies (2, 3). Almost 40% of young adults in high-income countries are expected to obtain a university degree during their lifetime (2). In Sweden, university students constitute a major part of the young adult population. The university period is accompanied by additional responsibilities and pressure to succeed, which may increase mental distress, depression or lead to excess alcohol use (4-7). In addition, university students have been found to experience low life satisfaction and to be more depressed

than a non-student population of a similar age (4, 6, 8-11). As a result, some students may succumb to suicidal ideation and a greater risk of dying by suicide (12-15).

Low educational attainment is associated with a higher risk of suicide as well as all-cause death (16-19). Previous studies of suicide risk in university students have predominantly compared students to the general population, without taking education attainment into account, finding similar or lower suicide rates for university students when compared to age-matched populations (20-25). However, by not considering differences in educational attainment, they may have underestimated the risk of suicide in university students.

Our aim was to investigate the risk of suicide in university students compared to non-students, while taking educational attainment into account. It was hypothesised that the risk of suicide would be higher during university studies compared to when having attained a university education.

METHODS

We included all Swedish residents aged 18-39 during 1993-2011 (N= 5,039,419). Newly turned 18-year-olds entered into the open cohort each year. The cohort was followed until 31 December, 2011. Subjects were censored at emigration, age 40, death or end of follow-up. Information on eligible residents, country of birth, and date of emigration was retrieved from the Register of the Total Population (Statistics Sweden), which is continuously updated with all births, deaths, immigration, emigration, and migration within Sweden (26).

Registration records for each academic year (spring and autumn) at university during 1993 through 2011 were obtained from the Administrative data for university and higher education

(Statistics Sweden). Highest attained level of education was retrieved from the Longitudinal Integration Database for Health Insurance and Labour Market studies (LISA, Statistics Sweden).

Dates and causes of death were retrieved from the Cause of Death Register (CDR, National Board of Health and Welfare), which contains all deaths of residents in Sweden since 1961 (27). The unique personal identification number assigned to all residents in Sweden was used for accurate linkage of information between the registers (28).

Classification of exposure

All participants were checked for registration at university for each year (1993-2011) during spring and autumn semesters - if there was no such record, person time was categorised according to educational attainment. For each subject throughout the study period, the current person-time was allocated to the corresponding educational category. Hence, subjects could contribute person time to more than one educational category; Figure 1 illustrates person time allocation and Figure 2 depicts 6 example subjects and their allocated person-time.

We defined ongoing university studies as being registered at university during the spring and/or autumn semester of each year. Since registration is not recorded instantly at the start of a semester, we defined the spring semester as starting from 1 March and continuing to 31 September, including the summer months (7/12 years), and the autumn semester lasting from 1 October to 28 February (5/12 years person-time) each year. Doctoral education was not included in this category.

For periods without registration at university, person-time was allocated to one of three different categories of non-student exposure, according to highest attained level of education: secondary

education or less (9 years of schooling, compulsory in Sweden), upper secondary education (12 years of schooling), and attained university education (tertiary education). The level of attained university education ranged from a minimum of one completed semester at university to finalised post-graduate education.

Outcomes

The main outcome was suicide, recorded in the Cause of Death Register as underlying cause of death according to the International Statistical Classification of Diseases and Related Health Problems (ICD, versions 9 and 10) as suicide (ICD-9: E950–E959, ICD-10: X60–X84) or as death with undetermined intent (ICD-9: E980-E989, ICD-10: Y10-Y34). Secondary outcomes were unnatural death (ICD-9: E800-E999 and ICD-10: V01-Y99, including suicide as above) and all-cause death (29).

Statistical analysis

Poisson regression analyses were used to examine the association between educational category and suicide by calculating the incidence rate ratio (IRR) with a 95% confidence interval (CI). We assessed person-time by adding the time the subjects were alive and living in Sweden under each of the exposure conditions. Attained university education was chosen as reference. Three regression models stratified by sex, were analysed; Model I crude model, Model II adjusted for age in three categories (18-24, 25-29, 30-39 years), and Model III (presented in text only), additionally adjusted for period (1993-1999, 2000-2005, 2006-2011). In a sensitivity analysis we excluded deaths with undetermined intent from the suicide outcome. Secondly, in order to

investigate any confounding effect of country of birth, we performed another sensitivity analysis where we excluded subjects born outside of Scandinavia.

SAS Genmod procedure was used to calculate IRRs and 95% CIs for suicide and other death. SAS v. 9.4 (SAS Institute Inc., Cary, NC, USA) was used.

RESULTS

The open cohort included 5,039,419 individuals, of whom 2,569,266 (51%) were men and 2,470,193 (49%) were women. We identified a total of 7 316 deaths due to suicide (Table 1), of which 541 were registered during ongoing university studies. Suicides constituted 63.4% of all unnatural deaths (N=11,533) and 29.7% of all deaths (N=24,672). During ongoing university studies, suicides constituted 71.4% of the unnatural deaths (N=757) and 36.4% of all deaths (N=1,485).

Rates of both suicide and all-cause death were highest for the exposure category with secondary or lower education and lowest for the category with attained university education. Suicide mortality rates for ongoing university studies were 19.0/100 000 person years for men and 7.2/100 000 person years for women (Table 1).

Table 1. Mortality rate per 100,000 person-years of suicides and all-cause deaths with 95% confidence intervals (CI) by sex and educational status, for individuals aged 18-39 during 1993-2011 in Sweden.

		Mortality					
		Suicide			All-cause death		
	Educational status	N	Rate	95%CI	N	Rate	95%CI
Men							
	Secondary or lower	1746	41.0	(39.1-42.9)	5 620	132.0	(128.6-135.5)
	Upper secondary	2766	22.3	(21.5-23.1)	8 761	70.6	(69.1-72.1)
	Ongoing university	358	19.0	(17.0-21.0)	907	48.2	(45.0-51.3)
	Attained university	539	10.4	(9.6-11.3)	1 813	35.1	(33.5-36.7)
Women							
	Secondary or lower	610	17.3	(15.9-18.7)	2 122	60.1	(57.6-62.7)
	Upper secondary	858	7.8	(7.3-8.3)	3 560	32.5	(31.4-33.5)
	Ongoing university	183	7.2	(6.2-8.3)	578	22.8	(21.0-24.7)
	Attained university	256	4.3	(3.8-4.9)	1 311	22.2	(21.0-23.4)

N=number of deaths.

The proportion of person-years in ongoing university studies (as students) was largest for 18-24-year-olds and lowest for 30-39-year-olds for both sexes (Table 2a and 2b). Inversely, the proportion of person-years of attained of university education was highest for 30-39-year-olds and lowest for 18-24-year-olds. In the age groups 18-24 and 25-29 years, larger proportions of female suicides, 8.6-18%, than male suicides, 7.2-12.5%, occurred during ongoing university studies over the three periods (Tables 2a and 2b).

Table 2a. Men's suicides and distribution of person-years by age, period and educational status in Sweden.

		1993-1999				2000-2005				2006-2011			
Age	Educational status	N. suic	% Suic	1000 Pyrs	% Pyrs	N. suic	% Suic	1000 Pyrs	% Pyrs	N. suic	% Suic	1000 Pyrs	% Pyrs
18-24	Secondary or lower	143	(39.0)	637	(25.6)	212	(51.2)	631	(29.3)	252	(46.5)	715	(28.6)
	Upper secondary	181	(49.3)	1375	(55.2)	165	(40.0)	1,093	(50.7)	212	(39.1)	1 295	(51.8)
	Ongoing university	42	(11.4)	343	(13.8)	37	(8.9)	346	(16.0)	68	(12.5)	380	(15.2)
	Attained university	1	(0.3)	135	(5.4)	6	(1.4)	87	(4.0)	10	(1.8)	113	(4.5)
25-29	Secondary or lower	131	(31.7)	284	(14.2)	107	(31.8)	181	(10.9)	170	(35.0)	218	(13.2)
	Upper secondary	221	(53.4)	1119	(56.2)	171	(50.9)	870	(52.4)	224	(46.1)	779	(47.1)
	Ongoing university	30	(7.2)	162	(8.2)	32	(9.5)	173	(10.4)	52	(10.7)	174	(10.5)
	Attained university	32	(7.7)	427	(21.4)	26	(7.7)	438	(26.4)	40	(8.2)	484	(29.2)
30-39	Secondary or lower	329	(30.0)	754	(19.0)	210	(24.4)	453	(12.1)	192	(21.8)	385	(10.9)
	Upper secondary	607	(55.1)	2 077	(52.4)	495	(57.6)	2 047	(54.4)	490	(55.6)	1 751	(49.6)
	Ongoing university	32	(2.9)	94	(2.4)	23	(2.7)	111	(2.9)	42	(4.8)	100	(2.8)
	Attained university	134	(12.2)	1039	(26.2)	132	(15.3)	1 150	(30.6)	158	(17.9)	1 296	(36.7)

N.= number of; Pyrs=person-years; Suic=suicides

Table 2b. Women's suicides and distribution of person-years by age, period and educational status in Sweden.

		1993-1999				2000-2005				2006-2011			
Age	Educational status	No. suic	%	1000 Pyrs	%	No. suic	%	1000 Pyrs	%	No. suic	%	1000 Pyrs	%
18-24	Secondary or lower	64	(45.0)	597	(24.4)	82	(59.0)	538	(26.2)	93	(47.0)	608	(25.5)
	Upper secondary	59	(41.5)	1272	(52.1)	44	(31.6)	951	(46.2)	74	(37.4)	1118	(47.0)
	Ongoing university	18	(12.7)	423	(17.3)	12	(8.6)	438	(21.3)	28	(14.1)	497	(20.9)
	Attained university	1	(0.7)	152	(6.2)	1	(7.2)	130	(6.3)	3	(1.5)	157	(6.6)
25-29	Secondary or lower	45	(34.6)	255	(13.0)	33	(27.0)	142	(8.9)	38	(27.1)	153	(9.7)
	Upper secondary	54	(41.5)	1066	(54.5)	56	(45.9)	708	(44.4)	57	(40.7)	583	(37.1)
	Ongoing university	14	(10.8)	169	(8.6)	22	(18.0)	210	(13.2)	21	(15.0)	218	(13.9)
	Attained university	17	(13.1)	466	(23.8)	11	(9.0)	534	(33.5)	24	(17.1)	618	(39.3)
30-39	Secondary or lower	98	(26.3)	599	(15.4)	79	(24.7)	345	(9.5)	78	(22.7)	292	(8.6)
	Upper secondary	204	(54.8)	2043	(52.4)	162	(50.6)	1828	(50.5)	148	(43.0)	1,395	(40.9)
	Ongoing university	22	(5.9)	161	(4.1)	16	(5.0)	222	(6.1)	30	(8.7)	195	(5.7)
	Attained university	48	(12.9)	1099	(28.2)	63	(19.7)	1223	(33.8)	88	(25.6)	1532	(44.9)

Pyrs=person-years; Suic=suicides

Table 3 presents IRRs for the association between educational status and suicide or all-cause death. In Model 2, adjusted for age, the IRRs indicated a higher risk during ongoing university studies compared to when having attained university studies, for men (IRR=2.37, 95% CI, 2.07-2.72) and for women (IRR=2.15, 95% CI, 1.77-2.61). The association was marginally stronger when additional adjustment for period was made (Model 3, not shown in table). A sensitivity analysis, excluding verdicts of undetermined intent from the suicide outcome, did not considerably change the estimates.

The IRR for all-cause mortality, adjusted for age (Model 2), also indicated a higher risk during ongoing university studies compared to after having attained at least one semester of university education. For men, IRR was 1.88 (95% CI, 1.73-2.04) and for women 1.55 (95% CI, 1.40-1.71).

For unnatural death the IRR indicated an approximately twofold higher risk during ongoing university studies compared to when having attained university education for men (IRR=2.02, 95% CI, 1.80-2.27) and for women (IRR=1.96, 95% CI, 1.67-2.30) (not shown in table). A sensitivity analysis revealed similar associations for all three outcomes for individuals born within and outside of Scandinavia.

Table 3. Incidence rate ratio (IRR) of suicide and all-cause death by educational status, with 95% confidence intervals (CI) for male and female Swedish residents aged 18-39, in 1993-2011. Attained university education is reference category

		Suicide		All-cause death	
		Model 1	**Model 2[1]**	**Model 1**	**Model 2[1]**
	Educational status				
Men	Secondary or lower	3.93 (3.57-4.33)	4.76 (4.31-5.25)	3.76 (3.57-3.97)	4.66 (4.41-4.91)
	Upper secondary	2.14 (1.95-2.34)	2.39 (2.18-2.62)	2.01 (1.91-2.12)	2.28 (2.17-2.40)
	Ongoing university	1.82 (1.60-2.08)	2.37 (2.07-2.72)	1.37 (1.27-1.49)	1.88 (1.73-2.04)
	Attained university	1	1	1	1
Women	Secondary or lower	3.99 (3.45-4.62)	4.90 (4.22-5.69)	2.71 (2.53-2.90)	3.67 (3.42-3.94)
	Upper secondary	1.81 (1.57-2.08)	2.01 (1.75-2.32)	1.46 (1.37-1.56)	1.71 (1.61-1.83)
	Ongoing university	1.67 (1.38-2.02)	2.15 (1.77-2.61)	1.03 (0.93-1.13)	1.55 (1.40-1.71)
	Attained university	1	1	1	1

[1]=Adjusted for age (18-24), (25-29) and (30-39).

DISCUSSION

In this nationwide cohort study, attending university studies was associated with a twofold risk of suicide compared to not being a student but having attained a university education. The risk was slightly higher for men than for women.

The population cohort, using large national registers of high quality and validity with complete nationwide coverage of exposure (ongoing university studies and educational attainment) as well as outcome (suicide and other death) and a long observation time, is unprecedented in university student suicide research and provides the present study with high generalisability and considerable power.

To the best of our knowledge, this is the first study of university student suicide that takes educational attainment in non-students into account. Results from previous studies may have been confounded due to differences in educational level. Low educational attainment is associated with a higher risk for both all-cause death and suicide (16-19). High educational attainment is associated with a better overall health and a lower mortality (19). However, a higher educational level is associated with a higher risk of suicide rather than other causes of death compared to those with a lower educational level (30).

Swedish suicide mortality statistics have proven to have a high level of accuracy when analysed for reliability (31). Still, in order to avoid any underestimation of the number of suicides in our cohort, we included death with undetermined intent, which is in line with several previous studies (32, 33). Retrospective analyses of deaths of undetermined intent suggest that these should be included in the definition of suicide (34) and all deaths in Sweden due to suicide or

undetermined intent are examined by forensic medicine. We conducted sensitivity analyses, excluding death by undetermined intent, to ensure that estimates of suicide risk did not substantially effect the results.

The generalisability of our results may be affected by the fact that education in Sweden is tuition free and that all university students are granted general financial aid during ongoing studies. In contrast to many other countries, this allows for anyone with sufficient motivation, grades and previous educational attainment to enter higher education. This is a longitudinal study of an entire national student population and therefore our results contribute with a higher representativeness than any previous study.

A recent study of university student suicides among mental health patients in the UK, found 214 deaths by suicide in the studied time period and no clear predominance for male suicides (35). In the present study we found a higher incidence rate ratio for male suicides among university students, yet the gap between men and women was smaller for students compared to non-students who had attained upper secondary education. Further, there was a tendency towards a larger proportion of female suicides occurring during ongoing university education.

The university student suicide rates found in the current study are higher than those reported in American studies of college and university students (20-25). We found a suicide rate for ongoing studies of 19.0/100,000 person-years for men, considerably higher than the suicide rate of 10.9/100,000 person-years for men in a study of 645 university and college campuses (20). Similarily, the suicide rate for women in the present study was higher, 7.2/100,000 person-years, compared to 3.1/100,000 person-years (20). Another study of suicide rates at 12 American university campuses found a rate of 10.0/100,000 person-years for men and 4.5/100 000 person-years for women (21). A comparison of U.S. university and college student suicide rates over

four eras from 1920-2004 found that the rate of suicide decreased over time from 13.4 in the first period to 6.5 in the most recent (22). One explanation for the differences in suicide rates may be that the educational systems are different in Sweden compared to the United States. Although exposure to the first university years in Sweden may be considered similar to U.S. college education, Swedish higher education, being tuition-free, may be considered more easily accessible. This may allow for a more heterogeneous student population in Sweden, with a larger proportion of vulnerable individuals. Further possible explanations to the differences in suicide rates may be that data from the national Swedish registers is more comprehensive and provides more accurate estimates. Previous studies have had concerns with possible underreporting of suicides from universities (26).

By comparing suicide risk during ongoing university studies to the risk according to attained level of education, our study provides a further differentiated picture of student suicide risk than previous studies. In a study of Oxford university students a slightly higher suicide rate than expected was found among 18-25-year-olds in England and Wales (23). However, two other British studies showed no difference in suicide rates between students at high ranking Oxford University and Cambridge University and suicide rates in the general population of the same age (24, 25).

As a considerable number of university students are older than 18-24 years we extended the age span of persons in the cohort up to 39 years. Most students with ongoing university studies are between 18 and 24 years of age and thus this age span contributed more to the main exposure, whereas most that had attained university were 30-39 years old and therefore contributed with more person-years to this reference category. This may explain why our estimates changed

considerably when adjusting for age. Further, students over 25 years of age have been found to have a significantly higher suicide risk than younger students (21).

It may be argued that those who have attained university education are a selected population that was never at risk of suicide during ongoing studies. However, the category of attained university education in the present study was considerably heterogeneous, including persons with only one completed semester as well as persons with a degree or even a doctoral education. Further, as individuals could move between exposure conditions, we argue that such an objection is weakened.

The present study shows a higher suicide risk during ongoing university studies, but we have not investigated possible explanations for this finding, which are most likely multifactorial and complex. The university or college environment presents demands and expectations of achievement which may cause considerable mental distress in some individuals (4-7). A recent study suggests that first onset suicidal behaviour and thoughts are more common in university students than in a general population sample (36). Depression, which is a risk factor for suicide, has been found to be more common among university students than in the general population (4, 5, 9). In a study of patients admitted to a psychiatric hospital after attempted suicide, university students were younger, used less violent methods and were less likely to have a history of substance abuse compared to other patients (37).

Future studies should investigate which specific risk factors, e.g. mental distress, performance-related anxiety, type of education and university, are associated with suicide risk in university students.

Conclusion

In conclusion, this national cohort study shows a twofold higher risk of death by suicide during ongoing university studies compared to during time as non-student with some prior terminated university education. University students who take their lives die from a preventable cause and despite being protected by known factors that decrease suicide risk such as having a high educational attainment. Our findings demonstrate the need of attention from public health efforts and student health care.

Legend: **Figure 1. Flow chart over allocation of person-time under exposure conditions.**

Legend: **Figure 2. An illustration of how exposure was measured according to educational status.**

The figure shows how person-time under the exposure *educational status* was assigned for six example persons (A-F) during a period of 10 years. If not currently studying at university, person-time for each subject was allocated to the exposure of highest attained education.
Person A) Is included year 0 at age 18. Attains upper secondary education after 1 year. Does not pursue university studies.
Person B) Is included year 0 at age 20. Has attained upper secondary education. Studies at university year 7-8. Dies year 9.
Person C) Is included year 3 when he reaches age 18. Has attained secondary education. Does not pursue further studies.
Person D) Is included year 0 at age 18. Attains upper secondary education after ½ year. Starts at university in August but is registered for the autumn semester in September, thus during year 2 has exposure of attained 12 years for 3 months and then pursues studies at university for 3 years. Attained university education from year 5 and on.
Person E) Is included year 0 at 33 years. Has attained university studies. Is censored year 7 when reaching age 40.
Person F) Is included year 4 at 18 years, has attained upper secondary education after 1 year. Starts university year 5, is registered after 3 months during which she has the exposure attained 12 years, moves abroad year 7 and is censored.

LISA= Longitudinal integration database for health insurance and labour market studies; AUH=Administrative data for university and higher education

Contributors: MD had the original idea for the study and designed it together with RL and MV. The authors are grateful to Professor Bo Runeson for his contribution in discussions of study design and results. MD and MV managed the dataset and Fredrik Mattson at FM Statistikkonsult has contributed with statistical analyses. CTL, MD, RL and MV interpreted results and co-wrote the paper. MD is guarantor.

Competing interests: All authors have completed the unified competing interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare no conflicts of interest with research granters and no financial relationships with commercial entities which may have an interest in the submitted work.

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Ethical approval: This study was approved by the Regional Ethical Review Board in Stockholm (diary number 2012-1669-31/5).

Data sharing: No additional data available.

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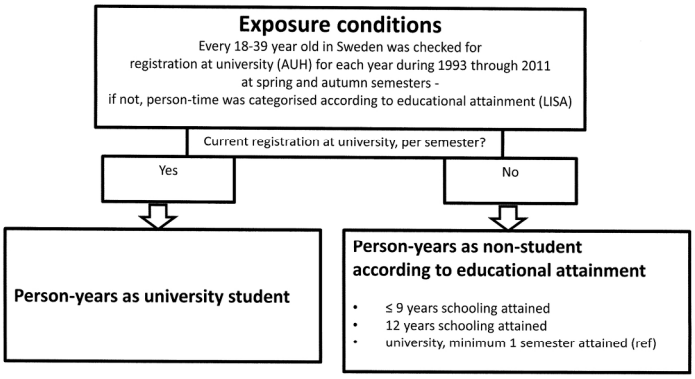

Figure 1. Flow chart over allocation of person-time under exposure conditions.

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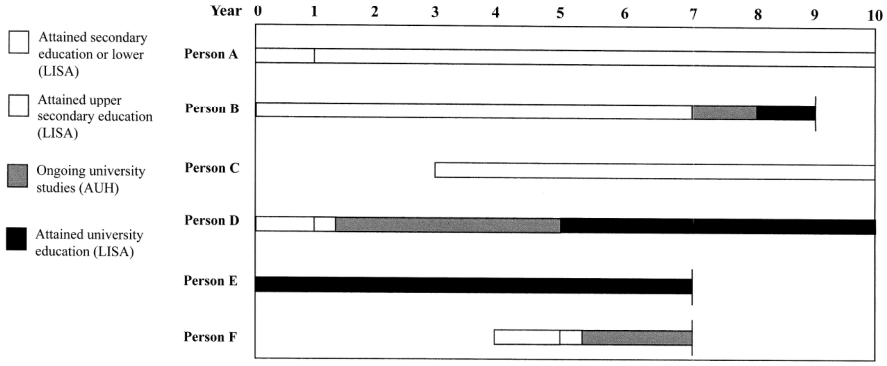

Figure 2. An illustration of how exposure was measured according to educational status.

209x148mm (300 x 300 DPI)

Ongoing university studies and the risk of suicide

A nationwide population-based cohort study of 5 million individuals in Sweden over a period of 18 years

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Our comments
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	The term "cohort study" is included in the title (**page 1**) as an indicator of the study design
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	An attempt to make an informative and balanced summary in the abstract can be viewed on **page 2**
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	On **pages 3-4** a scientific background and rationale for the study is reported
Objectives	3	State specific objectives, including any prespecified hypotheses	Specific objectives are stated on **page 4**
Methods			
Study design	4	Present key elements of study design early in the paper	Key elements of the study design are presented on **page 4.** Exposure is described on page 5.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Setting, dates, follow-up and data collection are described on **pages 4-6**.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Participants and methods of follow-up are described on **page 4.**
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Exposures are defined on **page 5** and in figure 1 and 2. Outcomes are defined on **page 6,** ICD diagnostic codes are presented. Confounders are mentioned on **pages 6-7 under Statistical Analysis.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Sources of data are stated on **pages 4-5**.
Bias	9	Describe any efforts to address potential sources of bias	Since the cohort covers the entire Swedish population in the studied age group and all data sources have full national coverage, bias is not a concern. Mentioned in the Discussion.
Study size	10	Explain how the study size was arrived at	Study size is described on **page 4**.

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	How categories were chosen is described on **page 6**.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	This is described on **pages 6-7**.
		(*b*) Describe any methods used to examine subgroups and interactions	**Page 7**
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, explain how loss to follow-up was addressed	Not applicable
		(*e*) Describe any sensitivity analyses	This is described on **page 7**
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	This is reported on **page 7**
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	**Figure 1**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	**Table 1**
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable.
		(c) Summarise follow-up time (eg. average and total amount)	Not applicable, but **Tables 2a and 2b** display amount of person years under each exposure.
Outcome data	15*	Report numbers of outcome events or summary measures over time	**Reported in Tables 1, 2a and 2b.**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	**Table 3**
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable.
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No absolute risks are reported.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Sensitivity analyses are reported on **page 11**.
Discussion			
Key results	18	Summarise key results with reference to study objectives	**Page 13**.

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	**Pages 14 and 16.**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	**Pages 13-16**.
Generalisability	21	Discuss the generalisability (external validity) of the study results	**Pages 14 and 15.**
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	**Page 17**.

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Ongoing university studies and the risk of suicide. A register-based nationwide cohort study of 5 million young and middle-aged individuals in Sweden, 1993-2011

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Ongoing university studies and the risk of suicide

A register-based nationwide cohort study of 5 million young and middle-aged individuals in Sweden, 1993-2011

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ABSTRACT

Objectives: To investigate the risk of suicide, unnatural death and all-cause death in university students compared to non-students, taking previous educational attainment into account.

Design: Open cohort study of all residents aged 18-39 and living in Sweden at any time between 1 January, 1993 and 31 December, 2011.

Setting: We linked data from national registers and calculated person years during university studies for three time periods (1993-1999, 2000-2005 and 2006-2011). Time as non-student was calculated and categorised according to attained educational level. Incidence rate ratios (IRR) with 95% confidence intervals (CI) were calculated with Poisson regression models, controlling for age and period.

Participants: The cohort consisted of 5,039,419 individuals, 51% men and 49% women.

Main outcome measures: Incidence of suicide (ICD-9: E950–E959, ICD-10: X60–X84) or death with undetermined intent (ICD-9: E980-E989, ICD-10: Y10-Y34), unnatural death (ICD-9: E800-E999 and ICD-10: V01-Y99) and all-cause death.

Results: A total of 7,316 deaths due to suicide were identified, of which 541 were registered among university students. The risk of suicide was twofold during ongoing university studies compared to when having attained university education, IRR 2.37 (95% CI: 2.07 to 2.72) in men and IRR 2.15 (95% CI: 1.77 to 2.61) in women.

Conclusions: Having ongoing university studies was associated with a higher risk of suicide compared to having attained university level education. This finding highlights the importance of achieving a deeper understanding of suicidal behaviour during years at university. Further studies should assess risk factors for suicide and suicidal behaviour in university students.

Strengths:

- The first study on mortality among university students in a large nationwide cohort.
- The high quality and validity of Swedish national registers with complete nationwide coverage of exposure and a long follow-up time.
- The first study taking educational attainment into account when estimating suicide risk among university students.

Limitations:

- Generalisability of our results may be affected by differences in educational standards between countries.
- We have not examined the possible predictors for an increased suicide risk in university students.

INTRODUCTION

Suicide is one of the leading causes of death in young people globally, where men are up to three times more likely than women to die by suicide (1). In several countries in the world an increasing proportion of young adults decide to pursue university studies (2, 3). Almost 40% of young adults in high-income countries are expected to obtain a university degree during their lifetime (2). In Sweden, university students constitute a major part of the young adult population. The university period is accompanied by additional responsibilities and pressure to succeed, which may increase mental distress, depression or lead to excess alcohol use (4-7). In addition, university students have been found to experience low life satisfaction and to be more depressed than a non-student population of a similar age (4, 6, 8-11). As a result, some students may succumb to suicidal ideation and a greater risk of dying by suicide (12-15).

Low educational attainment is associated with a higher risk of suicide as well as all-cause death (16-19). Previous studies of suicide risk in university students have predominantly compared students to the general population, without taking education attainment into account, finding similar or lower suicide rates for university students when compared to age-matched populations (20-25). However, by not considering differences in educational attainment, they may have underestimated the risk of suicide in university students.

Our aim was to investigate the risk of suicide in university students compared to non-students, while taking educational attainment into account. We hypothesised that the risk of suicide would be higher during university studies compared to when having attained a university education.

METHODS

We included all Swedish residents aged 18-39 during 1993-2011 (N= 5,039,419). Newly turned 18-year-olds entered into the open cohort each year. The cohort was followed until 31 December, 2011. Subjects were censored at emigration, age 40, death or end of follow-up. Information on eligible residents, country of birth, and date of emigration was retrieved from the Register of the Total Population (Statistics Sweden), which is continuously updated with all births, deaths, immigration, emigration, and migration within Sweden (26).

Registration records for each academic year (spring and autumn) at university during 1993 through 2011 were obtained from the Administrative data for university and higher education (Statistics Sweden). Highest attained level of education was retrieved from the Longitudinal Integration Database for Health Insurance and Labour Market studies (LISA, Statistics Sweden).

Dates and causes of death were retrieved from the Cause of Death Register (CDR, National Board of Health and Welfare), which contains all deaths of residents in Sweden since 1961 (27). The unique personal identification number assigned to all residents in Sweden was used for accurate linkage of information between the registers (28).

Classification of exposure

All participants were checked for registration at university for each year (1993-2011) during spring and autumn semesters - if there was no such record, person time was categorised according to educational attainment. For each subject throughout the study period, the current person-time was allocated to the corresponding educational category. Hence, subjects could contribute person time to more than one educational category; Figure 1 illustrates person time allocation and Figure 2 depicts 6 example subjects and their allocated person-time.

We defined ongoing university studies as being registered at university during the spring and/or autumn semester of each year. Since registration is not recorded instantly at the start of a semester, we defined the spring semester as starting from 1 March and continuing to 31 September, including the summer months (7/12 years), and the autumn semester lasting from 1 October to 28 February (5/12 years person-time) each year. Doctoral education was not included in this category.

For periods without registration at university, person-time was allocated to one of three different categories of non-student exposure, according to highest attained level of education: secondary education or less (9 years of schooling, compulsory in Sweden), upper secondary education (12 years of schooling), and attained university education (tertiary education). The level of attained

university education ranged from a minimum of one completed semester at university to finalised post-graduate education.

Outcomes

The main outcome was suicide, recorded in the Cause of Death Register as underlying cause of death according to the International Statistical Classification of Diseases and Related Health Problems (ICD, versions 9 and 10) as suicide (ICD-9: E950–E959, ICD-10: X60–X84) or as death with undetermined intent (ICD-9: E980-E989, ICD-10: Y10-Y34). Secondary outcomes were unnatural death (ICD-9: E800-E999 and ICD-10: V01-Y99, including suicide as above) and all-cause death (29).

Statistical analysis

Poisson regression analyses were used to examine the association between educational category and suicide by calculating the incidence rate ratio (IRR) with a 95% confidence interval (CI). We assessed person-time by adding the time the subjects were alive and living in Sweden under each of the exposure conditions. Attained university education was chosen as reference. Three regression models stratified by sex, were analysed; Model I crude, Model II adjusted for age in three categories (18-24, 25-29, 30-39 years), and Model III (presented in text only), additionally adjusted for period (1993-1999, 2000-2005, 2006-2011). To avoid bias from the inclusion of deaths with undetermined intent to the suicide outcome, we performed a sensitivity analysis where deaths with undetermined intent were excluded. Secondly, in order to investigate any

confounding effect of country of birth, we performed another sensitivity analysis where we excluded subjects born outside of Scandinavia.

SAS Genmod procedure was used to calculate IRRs and 95% CIs for suicide and other death. SAS v. 9.4 (SAS Institute Inc., Cary, NC, USA) was used.

RESULTS

The open cohort included 5,039,419 individuals, of whom 2,569,266 (51%) were men and 2,470,193 (49%) were women. We identified a total of 7,316 deaths due to suicide (Table 1), of which 541 were registered during ongoing university studies. Suicides constituted 63.4% of all unnatural deaths (N=11,533) and 29.7% of all deaths (N=24,672). During ongoing university studies, suicides constituted 71.4% of the unnatural deaths (N=757) and 36.4% of all deaths (N=1,485).

Rates of both suicide and all-cause death were highest for the exposure category with secondary or lower education and lowest for the category with attained university education. Suicide mortality rates for ongoing university studies were 19.0/100 000 person years for men and 7.2/100 000 person years for women (Table 1).

Table 1. Mortality rate per 100,000 person-years of suicides and all-cause deaths with 95% confidence intervals (CI) by sex and educational status, for individuals aged 18-39 during 1993-2011 in Sweden.

		Mortality					
		Suicide			All-cause death		
	Educational status	N	Rate	95%CI	N	Rate	95%CI
Men							
	Secondary or lower	1746	41.0	(39.1-42.9)	5 620	132.0	(128.6-135.5)
	Upper secondary	2766	22.3	(21.5-23.1)	8 761	70.6	(69.1-72.1)
	Ongoing university	358	19.0	(17.0-21.0)	907	48.2	(45.0-51.3)
	Attained university	539	10.4	(9.6-11.3)	1 813	35.1	(33.5-36.7)
Women							
	Secondary or lower	610	17.3	(15.9-18.7)	2 122	60.1	(57.6-62.7)
	Upper secondary	858	7.8	(7.3-8.3)	3 560	32.5	(31.4-33.5)
	Ongoing university	183	7.2	(6.2-8.3)	578	22.8	(21.0-24.7)
	Attained university	256	4.3	(3.8-4.9)	1 311	22.2	(21.0-23.4)

N=number of deaths.

The proportion of person-years in ongoing university studies (as students) was largest for 18-24-year-olds and lowest for 30-39-year-olds for both sexes (Table 2a and 2b). Inversely, the proportion of person-years of attained of university education was highest for 30-39-year-olds and lowest for 18-24-year-olds. In the age groups 18-24 and 25-29 years, larger proportions of female suicides, 8.6-18%, than male suicides, 7.2-12.5%, occurred during ongoing university studies over the three periods (Tables 2a and 2b).

Table 2a. Men's suicides and distribution of person-years by age, period and educational status in Sweden.

		1993-1999				2000-2005				2006-2011			
Age	Educational status	N. suic	% Suic	1000 Pyrs	% Pyrs	N. suic	% Suic	1000 Pyrs	% Pyrs	N. suic	% Suic	1000 Pyrs	% Pyrs
18-24	Secondary or lower	143	(39.0)	637	(25.6)	212	(51.2)	631	(29.3)	252	(46.5)	715	(28.6)
	Upper secondary	181	(49.3)	1375	(55.2)	165	(40.0)	1,093	(50.7)	212	(39.1)	1 295	(51.8)
	Ongoing university	42	(11.4)	343	(13.8)	37	(8.9)	346	(16.0)	68	(12.5)	380	(15.2)
	Attained university	1	(0.3)	135	(5.4)	6	(1.4)	87	(4.0)	10	(1.8)	113	(4.5)
25-29	Secondary or lower	131	(31.7)	284	(14.2)	107	(31.8)	181	(10.9)	170	(35.0)	218	(13.2)
	Upper secondary	221	(53.4)	1119	(56.2)	171	(50.9)	870	(52.4)	224	(46.1)	779	(47.1)
	Ongoing university	30	(7.2)	162	(8.2)	32	(9.5)	173	(10.4)	52	(10.7)	174	(10.5)
	Attained university	32	(7.7)	427	(21.4)	26	(7.7)	438	(26.4)	40	(8.2)	484	(29.2)
30-39	Secondary or lower	329	(30.0)	754	(19.0)	210	(24.4)	453	(12.1)	192	(21.8)	385	(10.9)
	Upper secondary	607	(55.1)	2 077	(52.4)	495	(57.6)	2 047	(54.4)	490	(55.6)	1 751	(49.6)
	Ongoing university	32	(2.9)	94	(2.4)	23	(2.7)	111	(2.9)	42	(4.8)	100	(2.8)
	Attained university	134	(12.2)	1039	(26.2)	132	(15.3)	1 150	(30.6)	158	(17.9)	1 296	(36.7)

N.= number of; Pyrs=person-years; Suic=suicides

Table 2b. Women's suicides and distribution of person-years by age, period and educational status in Sweden.

		1993-1999				2000-2005				2006-2011			
Age	Educational status	No. suic	%	1000 Pyrs	%	No. suic	%	1000 Pyrs	%	No. suic	%	1000 Pyrs	%
18-24	Secondary or lower	64	(45.0)	597	(24.4)	82	(59.0)	538	(26.2)	93	(47.0)	608	(25.5)
	Upper secondary	59	(41.5)	1272	(52.1)	44	(31.6)	951	(46.2)	74	(37.4)	1118	(47.0)
	Ongoing university	18	(12.7)	423	(17.3)	12	(8.6)	438	(21.3)	28	(14.1)	497	(20.9)
	Attained university	1	(0.7)	152	(6.2)	1	(7.2)	130	(6.3)	3	(1.5)	157	(6.6)
25-29	Secondary or lower	45	(34.6)	255	(13.0)	33	(27.0)	142	(8.9)	38	(27.1)	153	(9.7)
	Upper secondary	54	(41.5)	1066	(54.5)	56	(45.9)	708	(44.4)	57	(40.7)	583	(37.1)
	Ongoing university	14	(10.8)	169	(8.6)	22	(18.0)	210	(13.2)	21	(15.0)	218	(13.9)
	Attained university	17	(13.1)	466	(23.8)	11	(9.0)	534	(33.5)	24	(17.1)	618	(39.3)
30-39	Secondary or lower	98	(26.3)	599	(15.4)	79	(24.7)	345	(9.5)	78	(22.7)	292	(8.6)
	Upper secondary	204	(54.8)	2043	(52.4)	162	(50.6)	1828	(50.5)	148	(43.0)	1,395	(40.9)
	Ongoing university	22	(5.9)	161	(4.1)	16	(5.0)	222	(6.1)	30	(8.7)	195	(5.7)
	Attained university	48	(12.9)	1099	(28.2)	63	(19.7)	1223	(33.8)	88	(25.6)	1532	(44.9)

Pyrs=person-years; Suic=suicides

Table 3 presents IRRs for the association between educational status and suicide or all-cause death. In Model 2, adjusted for age, the IRRs indicated a higher risk during ongoing university studies compared to when having attained university studies, for men (IRR=2.37, 95% CI, 2.07-2.72) and for women (IRR=2.15, 95% CI, 1.77-2.61). The association was marginally stronger when additional adjustment for period was made (Model 3, not shown in table). A sensitivity analysis, excluding verdicts of undetermined intent from the suicide outcome, did not considerably change the estimates.

The IRR for all-cause mortality, adjusted for age (Model 2), also indicated a higher risk during ongoing university studies compared to after having attained at least one semester of university education. For men, IRR was 1.88 (95% CI, 1.73-2.04) and for women 1.55 (95% CI, 1.40-1.71).

For unnatural death the IRR indicated an approximately twofold higher risk during ongoing university studies compared to when having attained university education for men (IRR=2.02, 95% CI, 1.80-2.27) and for women (IRR=1.96, 95% CI, 1.67-2.30) (not shown in table). A sensitivity analysis revealed similar associations for all three outcomes for individuals born within and outside of Scandinavia.

Table 3. Incidence rate ratio (IRR) of suicide and all-cause death by educational status, with 95% confidence intervals (CI) for men and women aged 18-39, residents in Sweden, between 1993-2011. Attained university education is reference category.

		Suicide		All-cause death	
	Educational status	**Model 1**	**Model 2[1]**	**Model 1**	**Model 2[1]**
Men	Secondary or lower	3.93 (3.57-4.33)	4.76 (4.31-5.25)	3.76 (3.57-3.97)	4.66 (4.41-4.91)
	Upper secondary	2.14 (1.95-2.34)	2.39 (2.18-2.62)	2.01 (1.91-2.12)	2.28 (2.17-2.40)
	Ongoing university	1.82 (1.60-2.08)	2.37 (2.07-2.72)	1.37 (1.27-1.49)	1.88 (1.73-2.04)
	Attained university	1	1	1	1
Women	Secondary or lower	3.99 (3.45-4.62)	4.90 (4.22-5.69)	2.71 (2.53-2.90)	3.67 (3.42-3.94)
	Upper secondary	1.81 (1.57-2.08)	2.01 (1.75-2.32)	1.46 (1.37-1.56)	1.71 (1.61-1.83)
	Ongoing university	1.67 (1.38-2.02)	2.15 (1.77-2.61)	1.03 (0.93-1.13)	1.55 (1.40-1.71)
	Attained university	1	1	1	1

[1]=Adjusted for age (18-24), (25-29) and (30-39).

DISCUSSION

In this nationwide cohort study, attending university studies was associated with a twofold risk of suicide compared to not being a student but having attained a university education. The risk was slightly higher for men than for women.

The population cohort, using large national registers of high quality and validity with complete nationwide coverage of exposure (ongoing university studies and educational attainment) as well as outcome (suicide and other death) and a long observation time, is unprecedented in university student suicide research and provides the present study with high generalisability, negligible bias due to selection or loss to follow-up, as well as considerable power.

To the best of our knowledge, this is the first study of university student suicide that takes educational attainment in non-students into account. Results from previous studies may have been confounded due to differences in educational level. Low educational attainment is associated with a higher risk for both all-cause death and suicide (16-19). High educational attainment is associated with a better overall health and a lower mortality (19). However, a higher educational level is associated with a higher risk of suicide rather than other causes of death compared to those with a lower educational level (30).

Swedish suicide mortality statistics have proven to have a high level of accuracy when analysed for reliability (31). Still, in order to avoid any underestimation of the number of suicides in our cohort, we included death with undetermined intent, which is in line with several previous studies (32, 33). Retrospective analyses of deaths of undetermined intent suggest that these should be included in the definition of suicide (34) and all deaths in Sweden due to suicide or undetermined intent are examined by forensic medicine. To investigate whether suicide risk

estimates were biased, we conducted sensitivity analyses, excluding death by undetermined intent, which did not substantially effect estimates.

The generalisability of our results may be affected by the fact that education in Sweden is tuition free and that all university students are granted general financial aid during ongoing studies. In contrast to many other countries, this allows for anyone with sufficient motivation, grades and previous educational attainment to enter higher education. This is a longitudinal study of an entire national student population and therefore our results contribute with a higher representativeness than any previous study.

A recent study of university student suicides among mental health patients in the UK, found 214 deaths by suicide in the studied time period and no clear predominance for male suicides (35). In the present study we found a higher incidence rate ratio for male suicides among university students, yet the gap between men and women was smaller for students compared to non-students who had attained upper secondary education. Further, there was a tendency towards a larger proportion of female suicides occurring during ongoing university education.

The university student suicide rates found in the current study are higher than those reported in American studies of college and university students (20-25). We found a suicide rate for ongoing studies of 19.0/100,000 person-years for men, considerably higher than the suicide rate of 10.9/100,000 person-years for men in a study of 645 university and college campuses (20). Similarily, the suicide rate for women in the present study was higher, 7.2/100,000 person-years, compared to 3.1/100,000 person-years (20). Another study of suicide rates at 12 American university campuses found a rate of 10.0/100,000 person-years for men and 4.5/100 000 person-years for women (21). A comparison of U.S. university and college student suicide rates over four eras from 1920-2004 found that the rate of suicide decreased over time from 13.4 in the first

period to 6.5 in the most recent (22). One explanation for the differences in suicide rates may be that the educational systems are different in Sweden compared to the United States. Although exposure to the first university years in Sweden may be considered similar to U.S. college education, Swedish higher education, being tuition-free, may be considered more easily accessible. This may allow for a more heterogeneous student population in Sweden, with a larger proportion of vulnerable individuals. Further possible explanations to the differences in suicide rates may be that data from the national Swedish registers is more comprehensive and provides more accurate estimates. Previous studies have had concerns with possible underreporting of suicides from universities (26).

By comparing suicide risk during ongoing university studies to the risk according to attained level of education, our study provides a further differentiated picture of student suicide risk than previous studies. In a study of Oxford university students a slightly higher suicide rate than expected was found among 18-25-year-olds in England and Wales (23). However, two other British studies showed no difference in suicide rates between students at high ranking Oxford University and Cambridge University and suicide rates in the general population of the same age (24, 25).

As a considerable number of university students are older than 18-24 years we extended the age span of persons in the cohort up to 39 years. Most students with ongoing university studies are between 18 and 24 years of age and thus this age span contributed more to the main exposure, whereas most that had attained university were 30-39 years old and therefore contributed with more person-years to this reference category. This may explain why our estimates changed considerably when adjusting for age. Further, students over 25 years of age have been found to have a significantly higher suicide risk than younger students (21).

Some limitations should be mentioned. Although a nationwide study, our results may not be generalisable to students in countries whose educational systems differ substantially from the Swedish. It may furthermore be argued that those who have attained university education are a selected population that was never at risk of suicide during ongoing studies. However, the category of attained university education in the present study was considerably heterogeneous, including persons with only one completed semester as well as persons with a degree or even a doctoral education. Further, as individuals could move between exposure conditions, we argue that such an objection is weakened.

Most importantly, we have not investigated possible explanations for the higher suicide risk during ongoing university studies. These are most likely multifactorial and complex. The university or college environment presents demands and expectations of achievement which may cause considerable mental distress in some individuals (4-7). A recent study suggests that first onset suicidal behaviour and thoughts are more common in university students than in a general population sample (36). Depression, which is a risk factor for suicide, has been found to be more common among university students than in the general population (4, 5, 9). In a study of patients admitted to a psychiatric hospital after attempted suicide, university students were younger, used less violent methods and were less likely to have a history of substance abuse compared to other patients (37).

Future studies should investigate which specific risk factors, e.g. mental distress, performance-related anxiety, type of education and university, are associated with suicide risk in university students.

Conclusion

In conclusion, this national cohort study shows a twofold higher risk of death by suicide during ongoing university studies compared to during time as non-student with some prior terminated university education. University students who take their lives die from a preventable cause and despite being protected by known factors that decrease suicide risk such as having a high educational attainment. Our findings demonstrate the need of attention from public health efforts and student health care.

Legend: **Figure 1. Flow chart over allocation of person-time under exposure conditions.**

Legend: **Figure 2. An illustration of how exposure was measured according to educational status.**

The figure shows how person-time under the exposure *educational status* was assigned for six example persons (A-F) during a period of 10 years. If not currently studying at university, person-time for each subject was allocated to the exposure of highest attained education.
Person A) Is included year 0 at age 18. Attains upper secondary education after 1 year. Does not pursue university studies.
Person B) Is included year 0 at age 20. Has attained upper secondary education. Studies at university year 7-8. Dies year 9.
Person C) Is included year 3 when he reaches age 18. Has attained secondary education. Does not pursue further studies.
Person D) Is included year 0 at age 18. Attains upper secondary education after ½ year. Starts at university in August but is registered for the autumn semester in September, thus during year 2 has exposure of attained 12 years for 3 months and then pursues studies at university for 3 years. Attained university education from year 5 and on.
Person E) Is included year 0 at 33 years. Has attained university studies. Is censored year 7 when reaching age 40.
Person F) Is included year 4 at 18 years, has attained upper secondary education after 1 year. Starts university year 5, is registered after 3 months during which she has the exposure attained 12 years, moves abroad year 7 and is censored.

LISA= Longitudinal integration database for health insurance and labour market studies; AUH=Administrative data for university and higher education

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Competing interests: All authors have completed the unified competing interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare no conflicts of interest with research granters and no financial relationships with commercial entities which may have an interest in the submitted work.

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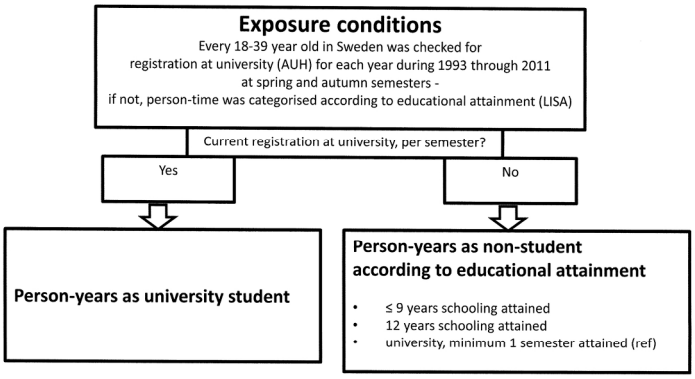

Figure 1. Flow chart over allocation of person-time under exposure conditions.

205x144mm (300 x 300 DPI)

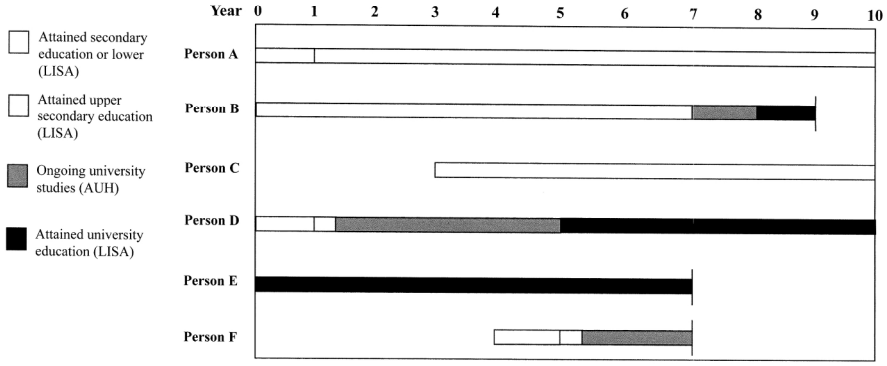

Figure 2. An illustration of how exposure was measured according to educational status

209x148mm (300 x 300 DPI)

Ongoing university studies and the risk of suicide

A nationwide population-based cohort study of 5 million individuals in Sweden over a period of 18 years

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Our comments
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	The term "cohort study" is included in the title (**page 1**) as an indicator of the study design
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	An attempt to make an informative and balanced summary in the abstract can be viewed on **page 2**
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	On **pages 3 and 4** a scientific background and rationale for the study is reported
Objectives	3	State specific objectives, including any prespecified hypotheses	Specific objectives are stated on **page 4**
Methods			
Study design	4	Present key elements of study design early in the paper	Key elements of the study design are presented on **page 4.** Exposure is described on **page 5**.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Setting, dates and follow-up is described on **page 4** under Methods. Data collection is described on **page 5**, exposure on **pages 5 and 6**.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Participants and methods of follow-up are described on **page 4.**
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Exposures are defined on **page 5** and in **figure 1** and **2**. Outcomes are defined on **page 6,** ICD diagnostic codes are presented. Confounders are mentioned on **page 7 under Statistical Analysis.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Sources of data are stated on **pages 4** and **5**.
Bias	9	Describe any efforts to address potential sources of bias	Since the cohort covers the entire Swedish population in the studied age group and all data

			sources have full national coverage, selection bias or bias due to loss to follow-up is of negligible concern. The handling of possible biased estimates due to the inclusion of deaths with undetermined intent with the suicide outcome is described on **page 6 under** Statistical analysis and also on **pages 13 and 14 under Discussion**.
Study size	10	Explain how the study size was arrived at	Study size is described on **page 4**.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	How categories were chosen is described on **page 6**.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	This is described on **pages 6 and 7**.
		(*b*) Describe any methods used to examine subgroups and interactions	**Pages 6 and 7.**
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, explain how loss to follow-up was addressed	Not applicable
		(*e*) Describe any sensitivity analyses	This is described on **page 6 and 7.**
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	This is reported on **page 7**
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	**Figure 1**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	**Table 1**
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable.
		(c) Summarise follow-up time (eg. average and total amount)	Not applicable, but **Tables 2a and 2b** display amount of person years under each exposure.
Outcome data	15*	Report numbers of outcome events or summary measures over time	**Reported in Tables 1, 2a and 2b.**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	**Table 3.** Confounders adjusted for are described on **page 13**.

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable.
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No absolute risks are reported.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Sensitivity analyses are reported on **page 11**.
Discussion			
Key results	18	Summarise key results with reference to study objectives	**Page 13**.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Limitations are discussed on p**ages 13 and 14**, possible imprecision is mentioned on **page 16.**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	A cautious overall interpretation is given on **page 13** and in under Conclusion on **page 17**. Results from similar studies in discussed on **page 14**, limitations are interpreted on **page 16** and other relevant evidence is put forward on **page 15**.
Generalisability	21	Discuss the generalisability (external validity) of the study results	**Pages 14, 15 and 16.**
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	**Page 17**.

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.