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ORIGINAL PAPER

Suicide mortality follow-up of the Swiss National Cohort (1990–2014): sex-specific risk estimates by occupational socio-economic group in working-age population

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Abstract

Purpose To identify occupations and socio-economic groups with detrimental or protective effect on suicide mortality.

Methods For every occupation and economic activity/industry, we computed directly age-standardized mortality rates (DSRs) using the age structure of the European population (2010) and standardized mortality ratios (SMRs) for suicide using national cause-specific mortality rates. We further stratified analyses by socio-economic variables, job-skill level, and by three calendar periods (1990–1998/1999–2006/2007–2014).

Results The study sample comprised 5,834,618 participants (94,918,456 person-years). The highest DSRs were observed among unemployed/job-seeking group, in agricultural, fishery and related male workers, and in health and social activities female workers. The lowest DSRs were observed in real estate and renting, research and development, IT and other business activities in men and in agriculture, hunting and forestry industry in women. A consistent reduction in DSRs across three calendar periods was observed in men. In female corporate managers, DSRs increased over the 2007–2014 period compared with 1999–2006. Compared to general working-age population, unemployed/job-seeking people, manufacturing labourers, personal care and related workers, and motor vehicle drivers of both sexes were identified at risk of suicide. Moreover, an excess of suicide was observed among male material recording and transport clerks; nursing and midwife-associated professionals; and agricultural workers as well as among female writers and performing artists.

Conclusions The findings suggest the detrimental effect of low socioeconomic positions, including unemployment, with respect to suicide mortality and a relationship between suicide and poor psychosocial working conditions in elementary occupations. Sex-specific results need further investigation.

Keywords Longitudinal study · Job-skill level · Psychosocial conditions · Gender differences · Social inequality · Managers

Introduction

Suicide is among the top 20 causes of death worldwide and accounts for about 1 million deaths every year [1]. In Switzerland, suicide is the fourth leading cause of death and accounts for about 1000 deaths per year [2]. The age- and sex-standardized suicide rate in Switzerland is the fifth highest rate in Europe, after Hungary, Lithuania, Estonia, and Finland [3]. Suicides result in the loss of approximately 18,000 potential years of life each year (13% of the potential years of life lost in Switzerland), as much as the number of years of life lost due to accidents [4]. Given the known importance of work in our everyday lives, and growing economic and psychosocial pressure related to rapid changes in current working conditions, the link between occupation

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and suicide regains both academic and practical interest. The meta-analysis conducted by Milner et al. [5] showed that the differences in suicide mortality between occupational groups seemed to depend on the skill level of these groups with lower rates of suicide in the highest skilled occupational group. Later studies [6, 7] showed that these differences hold mostly for men; they remain more controversial among women. Favourable working conditions, higher income, and educational background may explain reduced risk in men and women in high-skilled jobs. Conversely, poor psychosocial working conditions and socio-economic factors may explain the higher risk of suicide in elementary occupations [8]. Yet, results restricted to women are rare and remain controversial, in particular for the lowest skilled occupational group. Relatively few studies have examined sex differences in occupational suicide risk and even fewer reached sufficient statistical power. The reason is that suicide occurs less often in women than in men, which results in women being under-represented in some occupational groups. Halonen et al. [6], who modelled suicide rates in a large working population sample, found that sex was the most important of the examined predictors of suicide, followed by marital status, occupational group, unemployment, and age, while income was the least important predictor. Indeed, sex alone, or any other factor can explain occupational gradients in suicide mortality. The causes of suicide differ within and between occupational groups and represent a multi-faceted combination of individual and contextual factors, including socio-environmental and work-related factors. The latter includes psychosocial factors such as low job control, high job demands, effort–reward imbalance, and job insecurity. However, the complexity of the relationship between these psychological job stressors, suicidality and suicidal death requires more focused research, particularly concerning differences by country context, sex and occupation [8].

We explored sex-specific age-standardized suicide mortality rates across categories of occupation and economic activity in Switzerland and its variation over the past 24 years. Our aim was to identify both protective and adverse occupational settings with respect to risk of suicide, and compare them across three calendar periods, 1990–1998, 1999–2006, and 2007–2014.

Methods

Data sources

We used the Swiss National Cohort (SNC) to examine suicide rates in working-age population in Switzerland. The SNC is a large nation-wide longitudinal study of mortality based on linkage of census and mortality records. The SNC and details regarding the linkage process have been described in detail elsewhere [9, 10]. Briefly, the records of the 1990 and 2000 censuses were linked to death records or emigration records up to 2014 using deterministic and probabilistic linkage procedures, based on sex, date of birth, place of residence and other variables. The census was mandatory, with population coverage estimated at 98.6% [11]. National mortality rates were obtained from the Swiss Federal Statistical Office (SFSO).

Study population

To study the risk of suicide by occupational group, we considered the adults of working age as population at risk. In Switzerland, the minimum legal age of employment is 15 and the age of majority is 18; the statutory retirement age is 65 for men and 64 for women. All adults aged 18–65 years who were registered in the 1990 or 2000 census and included in the SNC were included.

Identification of suicides and related information

Suicides were identified based on the causes of death recorded on the death certificate. During 1990–1994, deaths caused by intentional self-harm were coded according to the International Classification of Diseases, Eighth Revision (ICD-8 codes 950–958), and from 1995 onwards based on the Tenth Revision (ICD-10 codes X60–X84). Suicides were classified by the following methods: (1) poisoning (ICD-8 950–952, ICD-10 X60–X69); (2) hanging (ICD-8 953, ICD-10 X70); (3) drowning (ICD-8 954, ICD-10 X71); (4) firearms (ICD-8 955, ICD-10 X72–X75); (5) cutting (ICD-8 956, ICD-10 X78); (6) jumping (ICD-8 957, ICD-10 X80); (7) railway (ICD-8 958.00, ICD-10 X81–X82); other (ICD-8 958 with exception of 958.00, ICD-10 83–84). The concomitant causes of deaths reported on the death certificates were examined and grouped by type of pathology, to identify the presence of morbidity, in particular psychiatric disorders, among participants who committed suicide.

Coding of occupation and economic activity/industry

The initial coding of occupations in both censuses was based on the Swiss classification of occupations (abbreviated as NSP, from *Nomenclature Suisse des Professions*), subsequently recoded using the four-digit codes of the International Standard Classification of Occupations, version 1988 (ISCO-88) by the SFSO. The recoding quality control was performed by comparing occupation codes between two censuses and between two coding systems (NSP and ISCO-88). The errors were corrected using a computer algorithm developed based on a review of cases for which ISCO-88 code was either inconsistent with NSP coding or not available.

When the NSP code did not correspond to any appropriate ISCO-88 code, it was converted into a three-digit ISCO code (subgroup), replacing the missing digit with 0. The coding of economic activity/industry was initially based on the National Classification of Economic Activities (abbreviated as WART from *Allgemeine Systematik der Wirtschaftszweige*), version 1985 in German in the 1990 census and on the National Classification of Economic Activities (abbreviated as NOGA from *Nomenclature Générale des Activités*) version 1995 in the 2000 census. To harmonize the coding, we recoded economic activity in 1990 into NOGA-1995, using a computer algorithm based on the official crosswalk between the two systems. NOGA-1995 corresponds to the Swiss adaptation of the General nomenclature of economic activities in the European Communities (abbreviated as NACE from *Nomenclature générale des Activités économiques dans les Communautés Européennes*) 1st revision, which in turn was based on the International Standard Classification of Industries (ISCI), 3rd revision.

Statistical analysis

Mortality follow-up started either on December 4th 1990 (the date of the 1990 census) or on December 5th 2000 (the date of the 2000 census). We followed all participants who were at least 18 years old at the beginning of follow-up up to the earliest of their 65th birthday, emigration, death or end of the study (December 31st 2014).

Occupation and economic activity were treated as time-dependent variables. For each occupation and each activity, person-years were assigned as follows:

- participants with a single occupation contributed to this occupation for the entire period of their follow-up;
- participants who changed occupation between 1990 and 2000 census, contributed to the first occupation between 1900 and 2000, and to the second one afterwards till the end of follow-up.

Being unemployed was considered as any other occupational category, based on the socio-professional status (SPS) variable.

Mortality from suicides was analysed using both direct and indirect standardization methods, separately for men and women. To allow for international comparisons of our results we computed directly age-standardized mortality rates (DSRs) per 100,000 person-years by applying the age–specific mortality rates observed in each occupational group to the age distribution of the 2010 European standard population. DSRs were computed over the entire study period and for the three calendar periods (1990–1998/1999–2006/2007–2014) with cut-offs corresponding to the WHO "Health for All" Framework Plan for the WHO European Region (WHO 1999) and the global financial crisis of 2007–2008. DSRs by economic activity were computed similarly.

To identify occupations and economic activities with suicide mortality statistically different from that of general Swiss population of working age, we computed standardized mortality ratios (SMRs) as the ratios of every occupational group's observed deaths to the expected deaths. The number of expected deaths was calculated by applying the national cause-specific mortality rates stratified by age (5-year groups) and calendar period (5-year groups), to the number of person-years for the corresponding calendar period and age group for every occupational and economic activity group. Furthermore, SMRs were calculated stratified by nationality, linguistic region, SPS, number of working hours per week and occupation skill-level, as defined by [5]. Bonferroni corrections were used to account for multiple comparisons. All analyses were conducted using STATA version 15 (StataCorp LP; TX, USA).

Results

Cohort description

The study population consisted of 5,834,618 participants (94,918,456 person-years), 49% of whom were women (Table 1). Figure 1 presents the flow chart of participants excluded because of age restriction. The follow-up characteristics were similar in men and women, with mean length of follow-up of 16 years. At study end-point (31/12/2014), 4% of participants had died ($n = 238{,}504$), 19,863 of whom by suicide. Among those who committed suicide, women were twice less than men and 2 years older than men on average. Sex differences were also observed in the distribution of participants by nationality (more non-Swiss among men), socio-professional category (twice more women not in paid employment and twice more men other self-employed), and occupational variables, including weekly working hours, occupation, and skill level. Occupation, activity sector, and weekly working hours were more often unknown or uncertain in women than in men (Table 1).

Directly age-standardized mortality rates (DSRs) by occupational group

The DSRs for suicide by occupation (2-digit ISCO-88) in men and women aged 18–65 are reported in Supplementary Tables S1 and S2, respectively. In men, the highest DSR over the 1990–2014 period was observed among unemployed/job-seeking group (52.94 per 100,000 person-years (95% CI 46.32–59.56), based on 568 suicides). Among working men, agricultural, fishery and related labourers (ISCO-88 = 92)

Table 1 Number of suicides among adults aged 18–65 years by sex and characteristics: the Swiss National Cohort (1990–2014)

Characteristics	Men				Women			
	n	%	No. of suicides	%	*n*	%	No. of suicides	%
Total	2,957,993	100	14,251[a]	100	2,876,625	100	5609	100
Person-years (in 100,000)	478.20				470.99			
Nationality								
Swiss	2,197,892	74	12,098	85	2,287,618	80	4896	87
Non-Swiss	760,101	26	2153	15	589,007	20	713	13
Socio-professional category								
Top management and independent professions	103,434	3	412	3	30,124	1	47	1
Other self-employed	262,966	9	1733	12	103,812	4	205	4
Professionals and senior management	247,788	8	1023	7	87,334	3	142	3
Supervisors/low-level management and skilled labourers	1,000,766	34	5711	40	829,073	29	1749	31
Unskilled employees and workers	283,168	10	1450	10	264,046	9	559	10
In paid employment, not classified elsewhere	475,647	16	1801	13	437,975	15	628	11
Unemployed/job-seeking	77,181	3	568	4	90,812	3	281	5
Not in paid employment	506,491	17	1548	11	1,032,828	36	1998	36
Unknown	552	0	5	0	621	0	0	0
1-digit ISCO-88[b]								
0 Armed forces	2367	0	12	0	63	0	0	0
1 Legislators, senior officials and managers	245,778	8	1058	7	73,883	3	133	2
2 Professionals	277,934	9	1191	8	128,431	4	266	5
3 Technicians and associate professionals	316,521	11	1736	12	320,958	11	625	11
4 Clerks	129,867	4	820	6	278,755	10	619	11
5 Service workers and shop and market sales workers	140,681	5	763	5	278,598	10	565	10
6 Skilled agricultural and fishery workers	78,861	3	575	4	23,560	1	46	1
7 Craft and related trades workers	415,594	14	2498	18	42,916	1	79	1
8 Plant and machine operators and assemblers	140,088	5	866	6	18,383	1	45	1
9 Elementary occupations	116,164	4	1053	7	100,573	3	378	7
Unknown	1,016,957	34	3111	22	1,519,693	53	2572	46
Job-skill level								
Lowest	116,164	4	1053	7	100,573	3	378	7
Second lowest	905,091	31	5522	39	642,212	22	1354	24
Second highest	316,521	11	1736	12	320,958	11	625	11
Highest	523,712	18	2249	16	202,314	7	399	7
Unknown	1,096,505	37	3691	26	1,610,568	56	2853	51
Weekly working hours								
1–5 h per week	12,235	0	38	0	72,085	3	104	2
6–19 h per week	36,613	1	154	1	261,797	9	455	8
20–27 h per week	45,249	2	284	2	234,092	8	514	9
28–35 h per week	54,282	2	306	2	171,602	6	317	6
36–39 h per week	35,729	1	124	1	49,534	2	87	2
40–45 h per week	1,580,518	53	7781	55	709,850	25	1289	23
46 and more hours per week	447,302	15	2233	16	110,340	4	201	4
Unknown	746,065	25	3331	23	1,267,325	44	2642	47
Language region								
German	2,120,386	72	10,369	73	2,042,499	71	3967	71
French	699,753	24	3412	24	694,517	24	1477	26
Italian	127,912	4	409	3	130,461	5	149	3
Rhaeto-Romansch	9942	0	61	0	9148	0	16	0

Table 1 (continued)

Characteristics	Men				Women			
	n	%	No. of suicides	%	*n*	%	No. of suicides	%
Vital status at end-point								
Alive	2,216,194	75			2,320,891	81		
Lost to follow-up	586,955	20			472,074	16		
Dead	154,844	5			83,660	3		
By suicide			14,251	100			5609	100
Suicide method								
Poisoning			2161	15			1850	33
Hanging			4111	29			1128	20
Jumping			1144	8			832	15
Railway			1047	7			683	12
Drowning			431	3			526	9
Firearms			4703	33			279	5
Other			285	2			171	3
Cutting			308	2			104	2
Blunt object			56	0			36	1
Steam, hot vapours and hot objects			4	0			0	0
Smoke, fire and flames			1	0			0	0
Age (years): mean ± standard deviation								
At study entry	36.6 ± 12.8				37.1 ± 13.1			
At study end	52.8 ± 11.5				53.4 ± 11.4			
At suicide	45.1 ± 11.7				47.4 ± 11.3			
Duration (years): mean ± standard deviation								
Follow-up	16.2 ± 7.2				16.4 ± 7.2			
Between the last occupational information and the suicide	5.5 ± 3.6				5.8 ± 3.6			

[a]In total, 14,254 males killed themselves during the period of study. However, three males committed suicide the first day of follow-up. As they do not account for any person-time, they were not included in the total

[b]ISCO-88 International Standard Classification of Occupations, 1988. It is a hierarchical nested tier classification allowing occupations to be classified from major groups (1 digit) to unit groups (4 digits)

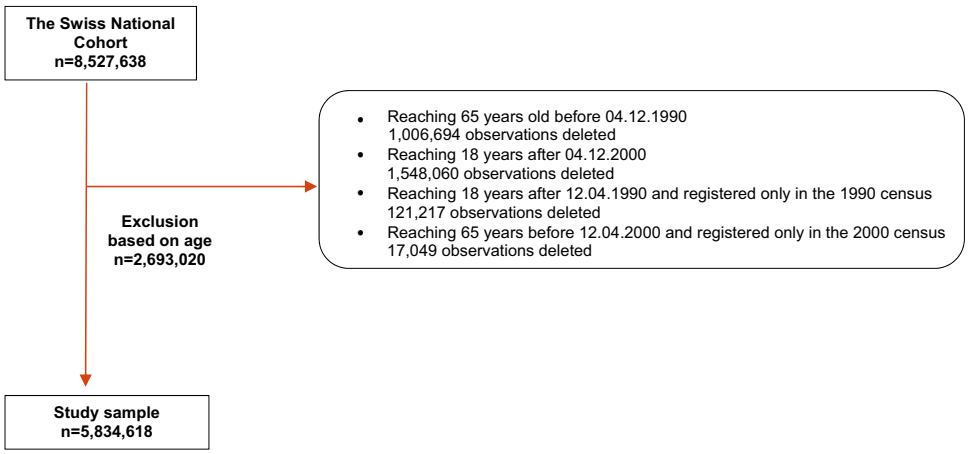
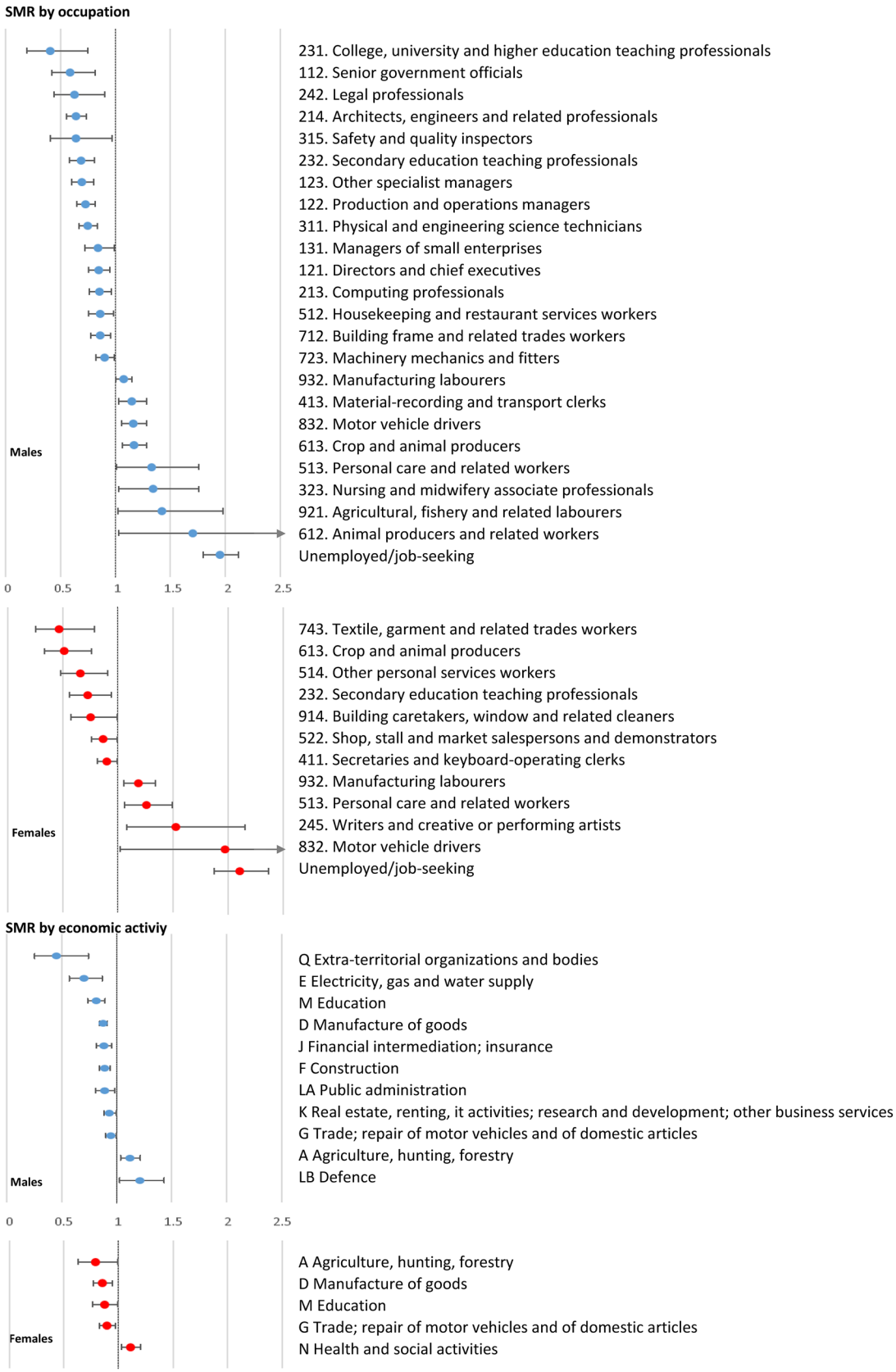


Fig. 1 Flowchart of study population selection

had the highest DSR (47.76), while drivers and mobile plant operators (ISCO-88 = 83), physical, mathematical and engineering science professionals (ISCO-88 = 92), labourers in mining, construction, manufacturing and transport (ISCO-88 = 93), stationary plant and related operators (ISCO-88 = 81), and other associate professionals (ISCO-88 = 34) were other top five occupational groups at risk of suicide, with DSR of 41.69, 37.87, 34.70, and 31.57 per


SMR by occupation
Males
231. College, university and higher education teaching professionals
112. Senior government officials
242. Legal professionals
214. Architects, engineers and related professionals
315. Safety and quality inspectors
232. Secondary education teaching professionals
123. Other specialist managers
122. Production and operations managers
311. Physical and engineering science technicians
131. Managers of small enterprises
121. Directors and chief executives
213. Computing professionals
512. Housekeeping and restaurant services workers
712. Building frame and related trades workers
723. Machinery mechanics and fitters
932. Manufacturing labourers
413. Material-recording and transport clerks
832. Motor vehicle drivers
613. Crop and animal producers
513. Personal care and related workers
323. Nursing and midwifery associate professionals
921. Agricultural, fishery and related labourers
612. Animal producers and related workers
Unemployed/job-seeking
0
0.5
1
1.5
2
2.5
Females
743. Textile, garment and related trades workers
613. Crop and animal producers
514. Other personal services workers
232. Secondary education teaching professionals
914. Building caretakers, window and related cleaners
522. Shop, stall and market salespersons and demonstrators
411. Secretaries and keyboard-operating clerks
932. Manufacturing labourers
513. Personal care and related workers
245. Writers and creative or performing artists
832. Motor vehicle drivers
Unemployed/job-seeking
SMR by economic activiy
Males
Q Extra-territorial organizations and bodies
E Electricity, gas and water supply
M Education
D Manufacture of goods
J Financial intermediation; insurance
F Construction
LA Public administration
K Real estate, renting, it activities; research and development; other business services
G Trade; repair of motor vehicles and of domestic articles
A Agriculture, hunting, forestry
LB Defence
0
0.5
1
1.5
2
2.5
Females
A Agriculture, hunting, forestry
D Manufacture of goods
M Education
G Trade; repair of motor vehicles and of domestic articles
N Health and social activities

◂**Fig. 2** Standardized mortality ratios (SMRs) for suicide by occupation (3-digit ISCO-88) and economic activity/industry (ISCI 3rd revision) among working age Swiss population stratified by gender (1990–2014). Only statistically significant results based on at least ten suicides are presented

100,000 person-years, respectively (Table S1). When DSRs were compared across the three calendar periods, a consistent decrease in suicide was observed in most occupation groups. The period 1990–1998 is characterised by the highest rates across the majority of occupations. Only legislators and senior officials, managers of small enterprises, physical, mathematical and engineering science professionals and customer service clerks exhibited higher rates over 1999–2006, compared to 1990–1998, though associated 95%-confidence intervals were partially overlapping. Corporate managers (ISCO-88 = 22), other professionals (ISCO-88 = 24), life science and health professionals (ISCO-88 = 32), agricultural, fishery and related labourers (ISCO-88 = 92), skilled agricultural and fishery workers (ISCO-88 = 11) and labourers in mining, construction, manufacturing and transport (ISCO-88 = 93) were occupational groups without notable reduction in DSRs over the 2007–2014 period compared to 1999–2006. The reduction in DSRs over the three calendar periods was obvious in all economic activities/industries, but for mining and quarrying, electricity, gas and water supply, transport and communication, and other community, social and personal service activities (Table S3).

Among women, the observed DSRs by occupational group were generally less than half than the rates in men (Tables S2 and S4). Health and social activities, other community, social and personal service activities, and education were the three economic sectors with the highest DSR over 1990–2014. Teaching associate professionals (ISCO-88 = 33), unemployed/job-seeking women, labourers in mining, construction and transport (ISCO-88 = 93), life science and health professionals (ISCO-88 = 22), and other professionals (ISCO-88 = 24) presented the five highest DSRs of suicide. Comparing the three studied periods, the decrease in DSRs was less obvious, and much smaller than in males. Moreover, among corporate managers (ISCO-88 = 12) and especially managers of small enterprises (ISCO-88 = 13), other professionals (ISCO-88 = 24), and other associate professionals (ISCO-88 = 34), DSRs increased over the 2007–2014 period compared with 1999–2006.

Standardized mortality ratios (SMRs) by occupational group and economic activity

SMRs for suicide by occupation (3-digit ISCO-88) with at least ten observed suicides are reported in Table S5, while statistically significant SMRs are presented in Fig. 2. Among men, statistically significant under-mortality by suicide compared to the general Swiss male population of working age was observed in 15 of 82 occupations. The three most protected occupation groups with respect to suicide mortality were college, university and higher education teaching professionals (ISCO-88 = 231), senior government officials (ISCO-88 = 112), and legal professionals (ISCO-88 = 242). The top five occupations with excess in suicide mortality were animal producers and related workers (ISCO-88 = 612), agricultural, fishery and related labourers (ISCO-88 = 921), nursing and midwife associate professionals (ISCO-88 code 323), personal care and related workers (ISCO-88 = 513), and crop and animal producers (ISCO-88 = 613). Among women, statistically significant SMRs were observed in 11 of 82 occupations. The three lowest SMRs were found among textile garment and related trade workers (ISCO-88 = 743), crop and animal producers (ISCO-88 code 613), and other personal service workers (ISCO-88 = 514), while the three highest excesses in suicide mortality was found in motor vehicle drivers (ISCO-88 = 832), writers and creative or performing artists (ISCO-88 = 245) and personal care and related workers (ISCO-88 = 513). Noteworthy was the two-fold excess of suicide among unemployed/job-seeking men and women compared to the Swiss population of working age, and the 33% and 22% increase in suicide mortality among men and women with unknown/uncertain occupation, respectively (Table S5).

Agriculture, hunting and forestry, and defence were the only economic activities with statistically significant excess of suicide in Swiss working-age men (Table S6). In women, the economic activities with highest suicide SMRs were health and social activities, transport and communication, and domestic service, although only the first one was significant.

Stratified analyses revealed that Swiss nationality was associated with a 15% and 17% higher risk of suicide in men and women, respectively, compared to the general population. Occupations at lowest skill level presented a small borderline significant excess of suicide in both sexes, while the SMRs for suicides were lower than one for highest, and second highest skill level occupations in men, but not in women (Table 2). For men working 36 and more hours per week SMRs were lower than one, while working less than 35 h a week was associated with an increased mortality by suicide. Regarding the socio-professional category, being in paid employment not classified elsewhere, in not paid employment or unemployed was associated with an excess in suicide mortality in men and women.

The method used for suicide varied according to sex (Table 1) and occupation (Table S7). Most remarkable were the use of poisoning, preferentially chosen by males working in health and social activity but uncommon in all other male activities and occupations, and jumping from height among both females working in electricity, gas and water supply

Table 2 Mortality from suicide in Swiss working-age population (1990–2014) by selected socio-economic factors and by sex: the Swiss National Cohort (1990–2014)

Characteristics	Men					Women				
	No. of deaths	SMR[a]	(95% CI)[b]	DSR[c]	(95% CI)[b]	No. of deaths	SMR[a]	(95% CI)[b]	DSR[c]	(95% CI)[b]
Skill level										
Lowest	1053	1.04	(0.98–1.10)	32.87	(30.38–35.36)	378	1.05	(0.95–1.16)	12.02	(10.42–13.62)
Second lowest	5522	1.01	(0.99–1.04)	28.83	(27.79–29.86)	1354	0.94	(0.89–0.99)	9.56	(8.83–10.28)
Second highest	1736	0.92	(0.88–0.96)	25.95	(23.74–28.15)	625	0.99	(0.92–1.07)	10.41	(8.53–12.29)
Highest	2249	0.78	(0.75–0.82)	30.44	(18.30–42.58)	399	0.96	(0.87–1.06)	9.11	(8.09–10.14)
Uncertain	3691	1.40	(1.35–1.44)	35.94	(34.46–37.42)	2853	1.27	(1.23–1.32)	12.85	(12.15–13.55)
Weekly working hours										
1–5 h per week	38	1.27	(0.92–1.75)	37.92	(24.96–50.87)	104	0.87	(0.72–1.05)	9.12	(7.01–11.22)
6–19 h per week	154	1.26	(1.08–1.48)	40.64	(26.63–54.65)	455	0.83	(0.76–0.91)	8.53	(7.36–9.71)
20–27 h per week	284	1.52	(1.35–1.71)	47.61	(29.70–65.53)	514	0.98	(0.90–1.07)	10.65	(9.16–12.14)
28–35 h per week	306	1.30	(1.16–1.45)	35.54	(29.19–41.88)	317	0.92	(0.82–1.03)	9.38	(8.06–10.71)
36–39 h per week	124	0.86	(0.72–1.03)	22.40	(17.78–27.01)	87	0.92	(0.74–1.13)	8.23	(6.49–9.98)
40–45 h per week	7781	0.89	(0.88–0.91)	25.33	(24.37–26.28)	1289	1.00	(0.95–1.06)	10.24	(9.39–11.09)
46 and more hours per week	2233	0.94	(0.90–0.98)	26.03	(24.43–27.63)	201	0.94	(0.82–1.08)	8.75	(7.48–10.01)
Uncertain	3331	1.61	(1.55–1.66)	46.28	(44.50–48.05)	2642	1.35	(1.30–1.40)	14.02	(13.32–14.73)
Socio-professional category										
Top management and independent professions	412	0.81	(0.74–0.90)	21.17	(17.53–24.80)	47	1.00	(0.75–1.33)	9.05	(6.32–11.78)
Other self-employed	1733	1.16	(1.11–1.22)	33.17	(29.78–36.56)	205	0.97	(0.85–1.11)	9.65	(7.44–11.85)
Professionals and senior management	1023	0.70	(0.66–0.74)	22.76	(16.38–29.13)	142	0.84	(0.71–0.98)	7.77	(6.38–9.16)
Supervisors/low-level management and skilled labour	5711	0.94	(0.92–0.97)	26.71	(25.22–28.20)	1749	0.98	(0.93–1.02)	9.88	(8.88–10.88)
Unskilled employees and workers	1450	0.90	(0.85–0.95)	26.25	(24.73–27.77)	559	0.88	(0.81–0.96)	9.57	(8.59–10.56)
In paid employment, not classified elsewhere	1801	1.15	(1.10—1.21)	29.46	(27.66–31.26)	628	1.14	(1.05–1.23)	10.78	(9.59–11.96)
Unemployed/job-seeking	568	1.95	(1.80–2.12)	52.94	(46.32–59.56)	281	2.11	(1.87–2.37)	21.84	(16.85–26.84)
Not in paid employment	1548	1.76	(1.68–1.85)	53.57	(50.39–56.74)	1998	1.29	(1.23–1.35)	13.43	(12.60–14.26)
Nationality										
Swiss	12,098	1.15	(1.13–1.17)	32.64	(31.76–33.52)	4896	1.17	(1.13–1.20)	12.03	(11.50–12.56)
Non-Swiss	2153	0.65	(0.62–0.68)	18.42	(17.19–19.65)	713	0.80	(0.74–0.86)	8.18	(7.28–9.07)
Region language										
German	10,369	1.03	(1.01–1.05)	29.47	(28.59–30.35)	3967	1.09	(1.05–1.12)	11.33	(10.76–11.90)
French	3412	1.08	(1.04–1.11)	29.70	(28.35–31.05)	1477	1.23	(1.17–1.30)	12.33	(11.47–13.19)
Italian	409	0.70	(0.63–0.77)	23.32	(18.72–27.92)	149	0.65	(0.55–0.77)	6.40	(5.32–7.48)
Rhaeto-Romansch	61	1.28	(1.00–1.65)	36.24	(26.56–45.92)	16	0.96	(0.55–1.57)	–	–

Only results for categories including at least ten suicides are presented

[a] Standardized mortality ratios, based on the mortality rates of Swiss working-age (15–65 years) population;

[b] 95% confidence interval

[c] Directly age-standardized mortality rates (DSRs) based on the 2010 European Standard Population restricted to the 18–65 years age group

activity and material recording and transport clerks. In contrast, the presence of morbidity and psychiatric disorders (indicated in the death certificate of suicided participants) was equally distributed across occupation groups, but was slightly higher in women (61% and 40%, respectively) than in men (50% and 30%, respectively, data not shown).

Discussion

This study is one of the few to compare SMRs and DSRs per 100,000 person-years for every occupation and every economic activity/industry at national level [12]. We also described how the occupation-specific DSRs have changed over the past 24 years. The main strength of this study lies in its classification of occupations and economic activities/industries using standardized national and international coding frameworks. This enables comparisons of our results with those from other studies as well as investigations of higher-order patterns of occupation and suicide across the entire working population [5].

Whereas some authors recommended using managers/professionals [5] or teachers [13] as reference group to compare the suicide rates across occupations, we decided to use the general Swiss adult population as reference for identifying occupation groups at lowest and highest risk of suicide. For this first nationwide study, we preferred to make use of all available data, keeping the study sample as large as possible and including unemployed participants and those with unknown occupation. However, we were aware that using the general adult population could generate the healthy worker effect (HWE), a selection process such that those who remain employed tend to be healthier than those who leave employment [14]. The HWE has the effects of decreasing the SMRs and therefore may mask mortality excesses resulting from occupational exposures in employed populations. No evidence of such an effect was, however, observed in our data. Moreover, the choice of reference occupation is still being debated across countries and authors [13, 15, 16], the selection of one specific occupation with no relevant assumption for our national context, would complicate interpretation and comparison of our results. The quality of occupational information in the SNC is not perfect, as it precluded us from classifying occupation in 34% of males and 53% of females, corresponding to 22% and 46% of suicides deaths, respectively. However, given the national representativeness of the SNC [9, 17], we consider unlikely any potential of selection bias in our study, as confirmed by comparison of participants with known and unknown occupation by main sociodemographic variables (results not shown). Notwithstanding these issues, our study has a number of strengths, including its use of the best available quality population-level data on suicide, and coverage across a large nation representative sample over a 24-year period. The fact that our population is followed as a cohort is one of the major strengths of this study: exposure to potentially adverse conditions (here the occupational features) is thus assessed before the outcome of interest. A further strength is that these data are self-reported data rather than administrative data. By treating occupation and economic activity/industry as time-dependent variables, and those with uncertain or unknown occupation as a distinct occupation group, we were able to obtain reliable occupational information on the time before the suicide occurred; this data is thus free of any recall bias inherent to any retrospective study. The timespan between the last occupational information and suicide in this study was about 5 years in average and only 10% of the study sample had 10-year-older information. Thus, we believe that exposure misclassification is limited. The quality of data from death certificates in Switzerland is considered high in general, and since 1990, SFSO pays particular attention to suicide codification to specify assisted suicides [10, 18]. Moreover, the Swiss National Programme on suicide prevention allowed improving diagnosis and reporting of suicidal attempts and suicides [2]. Therefore, any misclassification of outcome seems unlikely.

Our results are consistent with the results of other studies and confirm the detrimental effect of low socioeconomic positions, including unemployment, with respect to suicide mortality [19–23]. Employment in elementary occupations, such as manufacturing labourers or personal care and related workers (at lowest and second lowest skill level), associated with excess of suicide in both sexes, is another consistent finding [5, 13, 24]. In agreement with prior reports [12, 16, 24–28], agriculture, hunting and forestry as well as defence in men and health and social activities sectors in women were identified as economic activities at risk of suicide. Our findings are also consistent with evidence that easy access to lethal means of suicide in healthcare and military personnel increases the mortality from suicide [24, 29, 30]. The excess risk in health and social activities sectors was shown to be due to the increased use of self-poisoning, a method that professionals know how to use effectively [13]. According to our data, poisoning was the most frequent lethal means used in health and social activities, in both men and women (Table S7), while nursing and midwifery associate professionals (3-digit ISCO-88 = 323) along with personal care and related workers (3-digit ISCO-88 = 513) were the only occupations where men used poisoning as the preferred lethal means (Table S7). The use of firearms, the most frequent lethal means among men in general (33%), compared to women (5%) (Table 1), was particularly high in men (46%) but also in women (18%) employed in defence activity. Moreover, defence activity seems to be the only one where Swiss working-age women used firearms as the second preferred lethal means (as much as the railway suicides),

after poisoning. The firearm restriction resulting from the Swiss 2003 "Army XXI" reform was effective in reducing both the overall and firearm suicide rates [31]. Thus, our results corroborate the evidence that restricting access to the lethal means through the work would prevent suicide in these specific activities.

Some results seem to reflect national or sex-related specificities. For example, the agricultural worker over-mortality from suicide, well described in the literature [32–35], was observed only among men. By contrast, in Swiss women, agricultural occupations had a rather protective effect, which is an original finding in our study. Moreover, Swiss agricultural workers used preferentially hanging as lethal mean (52% of men and 39% of women), whereas firearms and poisoning have been considered the leading methods of suicide in agricultural, forestry and fishery workers elsewhere, due to easy access to weapons and toxic substances through their work [34].

Furthermore, the SMRs stratified by skill level, weekly working hours and SPS were different in men and women. The lack of statistical power may be one possible explanation to some not-significant results in women. Indeed, the number of female suicide is three-fold less than in men, and unavailability of occupation for 46% of female suicides negatively affected statistical power of our analysis. However, an alternative explanation may be a more complex interplay between occupation, suicide decision and other factors that requests further investigation [7, 36]. Nevertheless, we identified some particular female occupation groups at increased risk of suicide. Personal care and related female workers were one of them. A more detailed analysis, by 4-digit ISCO-88 revealed that most cases were institution-based personal care workers ($n = 67$); however, the highest risk of suicide was observed in child-care workers and in personal care workers not otherwise specified, with SMR = 1.29 and 1.33, based on 11 and 35 deaths, respectively (results not shown). This occupational group, known to be at high risk of suicidality and mental ill health more generally [12, 25, 37–39], was also identified in men. From our stratified analysis, we learned that suicided women had similar characteristics to the general women working population: mostly of Swiss nationality (87%), from German (70%) and French (25%) speaking regions, working 40–45 h a week (44%) in a job of second lowest skilled level (100%).

Motor vehicle female drivers were also at risk of suicide in this study, along with men. To our knowledge, only Andersen et al. [27] studied this occupation group, classified among 20 occupations at risk of suicide in Denmark. Yet, it was classified among transport activity sector, encompassing motorcycle, car, taxi and van drivers, and considered as male-dominated [13]. A more detailed analysis of this occupational group, by 4-digit ISCO-88 revealed that most cases in our study ($n = 9$) were motor vehicle drivers, not otherwise specified (ISCO-88 = 8320). Additional three cases were identified among bus and tram drivers (ISCO-88 = 8323), with corresponding SMR of 3.89, though statistically not significant. Women working as motor vehicle drivers exhibited similar characteristics as personal care and related female workers, but worked more often in excess of 40 h a week (57%), sometimes as self-employed (15%). The suicide method used by women in this occupational group (i.e., poisoning) did not differ from that used in other occupational groups. Thus, further investigation is necessary to identify the risk factors specific to this group.

Female writers and creative performance artists were a third occupation group with excess of suicide in women. Among them, authors, journalists and other writers were particularly at risk (SMR = 1.93). Schneider [40] has investigated the over-mortality of Swiss writers (men and women combined) compared to the mortality rates of Swiss population, and performed comparative analysis of suicide risk factors among creators, including writers, artists, philosophers, mathematicians and composers. He attributed the writers' over-risk of suicide to the "essential loneliness of the writer when wrestling with his emerging work", the immediateness of the process of writing and chronic exposure to introspection towards mostly autobiographic narration, where death appears very often [40]. Other explanation could include uncertainty over employment status (long bouts of unemployment/freelance status) and income level.

Surprisingly, the SMRs in non-Swiss people of working-age were significantly below one, contrasting with the over-mortality from suicide observed among working-age people with Swiss citizenship. No obvious reasons exist for this finding and we found no confirmatory data. According to the national data, non-Swiss people neither are considered as population at risk of suicide, nor under-recorded because of a selection process [4]. The proportion of non-Swiss participants in our study sample is very similar to that in the general population (23% and 24.6%, respectively). In contrast, migrants with uncertain status can be considered at risk of suicide, as 41% of randomly selected asylum seekers were found affected by a psychological problem, including severe depression and post-traumatic stress disorder [4, 41], a known risk factor for suicide. However, they are not part of the SNC, as by definition the SNC includes only permanent residents. We could speculate that the non-Swiss participants have a more difficult access to firearms because of the exemption of non-Swiss men from the compulsory military service and potentially stricter conditions for obtaining a gun license than Swiss citizens. Besides, a selection of non-Swiss workers who are healthier and mentally stronger than the average population through working and/or pay conditions offered in Switzerland could be hypothesized. Further confirmation of this finding is necessary, though. Our analysis of temporal trends showed a consistent reduction

in suicide rates in most occupation groups in men. Compared to the DSRs in the 1990–1998 period, males DSRs in 2007–2014 were halved. This may reflect a general reduction in suicide rates in Switzerland, highlighted by several authors, although regardless of occupation [18, 31]. Noteworthy, the decrease in DSRs over time was less notable in women than in men, and the only activity sector with obvious reduction in rates was working hotels and restaurants. In contrast, among corporate managers of both sexes and among female managers of small companies, DSRs were higher in the 2007–2014 period than in the previous period. The calendar period 2007–2014 encompassed the 3-year financial crisis that was found detrimental to workers' mental health [15] and associated with increase in suicide in all skill level jobs in Australian men and in tech/trade and professional female workers. In that study, managers formed the reference group and had no risk estimates. However, in Korea and Japan, managerial workers were compared with workers in elementary and sale occupations, respectively, and identified as the occupation group at highest risk of suicide. Business failure or excess debt following the global recession was reported as possible suicide reasons among managers [42, 43]. In our study, men in managerial occupations experienced significantly lower mortality from suicide compared to the general Swiss population. However, belonging to a high socio-professional category was protective against suicide only for men, to the exception of other self-employed men.

In women, the results were less conclusive, and comparable literature data is scarce. Hanebuth et al. [44] analysed burnout and related conditions in Swiss managers over 2006–2010 period and found that work strain had the most important apparent effect over time on burnout, vital exhaustion, and depression. Howard and Krannitz [36] recently demonstrated that work-family conflict, family–work conflict, lack of job autonomy and task variety, and job dissatisfaction are significantly linked to suicide attempts via depression and suicidal ideation. They recommended developing a theoretically derived nomological net around suicidal behaviour in workers and called for the reanalysis of relationship between suicide and occupation accounting for individual, social, and organizational factors within occupations in predicting suicide. Further analysis of our cohort combined with additional data should enable us to examine some of these factors directly and to consider why certain occupations may have higher suicide rates.

Concluding remarks

This study is the first one to report the DSRs and SMRs for suicides by occupation group and economic activity in Switzerland. It showed a clearly distinctive pattern of suicide mortality between the two sexes and identified occupation groups at high and low risk of suicide among men and women. Although we stratified SMRs by job-skill level and other socioeconomic characteristics, this study remains descriptive in nature. Though Milner et al. suggested using the job-skill level variable as proxy of psychosocial working conditions [5], only some of psychosocial job stressors (e.g., job control and job demand) are likely to reliably pattern by skill levels. The suggested relationship between suicide and poor psychosocial working conditions in elementary occupations and low socio-economic conditions in precarious occupation groups are in line with the recently proposed theoretical framework, especially in men. Sex-specific results need further investigation. In-depth analyses, taking into account the individual, social, and organizational characteristics of this population are necessary to understand the differences between and within protective and harmful occupations and to design targeted interventions aiming at suicide prevention among high-risk workers.

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Compliance with ethical standards

Conflict of interest This work was conducted in frame of the SNC nested study contract no. 2365. The authors have no conflicts of interest to declare.

Ethical approval The SNC and the present study were approved by the Cantonal Ethics Committees of Bern and Zurich, and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The manuscript does not contain clinical studies or patient data.

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