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CLINICAL RESEARCH
Prevention and epidemiology

Cardiovascular disease risk factors in relation to suicide mortality in Asia: prospective cohort study of over one million Korean men and women

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Aims

A potential role for cardiovascular disease (CVD) risk factors in the aetiology of suicide has not been comprehensively examined. In addition to being small in scale and poorly characterized, existing studies very rarely sample Asian populations in whom risk factor–suicide relationships may plausibly differ to Caucasian groups. We examined the association between a series of CVD risk factors and future mortality from suicide.

Methods and results

The Korean Cancer Prevention Study is a prospective cohort study comprising 1 234 927 individuals (445 022 women) aged 30–95 years with extensive measurement of established CVD risk factors at baseline and subsequent mortality surveillance. Fourteen years of follow-up gave rise to 472 deaths (389 in men and 83 in women) from suicide. After adjustment for a range of covariates, in men, smoking hazard ratio; 95% CI: (current vs. never: 1.69; 1.27, 2.24), alcohol intake (1–24 g/day vs. none: 1.29; 1.00, 1.66), blood cholesterol ($\geq$240 vs. $<$200 mg/dL: 0.54; 0.36, 0.80), body mass index (underweight vs. normal weight: 2.08; 1.26, 3.45), stature [quartile 1(lowest) vs. 4: 1.68; 1.23, 2.30], socioeconomic status [quartile 1(lowest) vs. 4: 1.65; 1.21, 2.24], and martial status (unmarried vs. other: 1.60; 0.83, 3.06) were related to suicide mortality risk. These associations were generally apparent in women, although of lower magnitude. Exercise and blood pressure were not associated with completed suicide.

Conclusion

In this cohort of Korean men and women, a series of CVD risk factors were associated with an elevated risk of future suicide mortality.

Keywords

Cardiovascular disease • Risk factors • Epidemiology • Suicide

Introduction

Although there is a long research tradition of studies examining the role of psychiatric and demographic risk factors in the aetiology of suicide,[1,2] the role of health-related behavioural and, particularly, biological indices is not well understood. These characteristics, all of which are also cardiovascular disease (CVD) risk factors in their own right[3] and have, *a priori*, been plausibly linked with suicide, include smoking, heavy alcohol consumption, obesity, physical inactivity, and raised levels of blood cholesterol and blood pressure.

While smoking[4–9] and higher levels of alcohol intake[10–12] are generally associated with a raised risk of suicide death in the modest collection of studies conducted, findings for other CVD risk indices are often contradictory. Thus, while high blood pressure,[13] obesity,[14,15] and low blood cholesterol[16–19] have

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been found to be associated with elevated suicide risk in some cohorts, others demonstrate that the same indices appear to confer protection[20–23] or reveal no association.[7,21,24] This highly discordant literature may be at least partially explained by the very low number of completed suicides in some studies leading to suboptimal statistical power, and a failure to take into account potentially important confounding variables.

This general paucity of information is particularly acute in women and non-Caucasian populations. Owing to the lower suicide rates in women than men, most investigators are not able to present gender-specific analyses. It is also the case that CVD risk factors and suicide mortality have been little examined in non-Caucasian populations where there are strong *prima facie* reasons to anticipate that these risk factors may have a different influence on suicide. Thus, historically, Asian societies have experienced different environmental exposures, genetic background, and socio-economic circumstances.

Against this background of inconsistent findings, methodological shortcomings of existing data, and paucity of evidence in non-Caucasian populations and in women, we explored the association of behavioural and biological CVD risk factors with suicide mortality in a large-scale, well-characterized cohort study of South Korean men and women. Based on analyses from 2004 for 30 OECD countries, South Korean females have the highest suicide death rate of all nations (13.0 per 100 000), while the males are ranked third at 30.3 per 100 000.[25] Thus, South Korea provides an ideal setting in which to enhance understanding of suicide aetiology.

Methods

The Korean Cancer Prevention Study (KPCS) comprises 1 329 525 individuals (482 618 women) aged 30–95 years who participated in at least one medical evaluation offered routinely by the Korean National Health Insurance Corporation between 1992 and 1995.[26–28] All South Koreans are registered with the National Health Insurance Corporation. Under this plan, all citizens are eligible to undergo such examinations. The Institutional Review Boards of Yonsei University and the Johns Hopkins University Bloomberg School of Public Health approved the study.

Cohort members underwent medical examinations at local hospitals during which blood pressure measurements were taken in a seated position using a standard mercury sphygmomanometer or automatic manometer. A fasting serum specimen was drawn and assayed for total cholesterol. Each hospital that participated in the examination had internal and external quality control procedures directed by the Korean Association of Laboratory Quality Control. History of cigarette smoking (never, former, current), alcohol consumption (g/day: ethanol), and exercise participation (yes, no) were self-reported by each participant. Weight and height of each subject were measured directly in light clothing with shoes removed; body mass index (BMI) was calculated in the usual manner (weight in kilograms divided by height in metres squared). Study members reported their marital status (married, not married, remarried, separated, divorced, widow). Our measure of socioeconomic status was the monetary contribution per year, in South Korean 'Won' (1112 Won = 1.00 US Dollar), made by the employee to their medical insurance scheme. This is means-calculated, being based on employee's income plus assets, such as ownership of property and automobiles.

Ascertainment of suicide mortality

Fatal outcomes in the study were ascertained from death certificates. Computerized searches for death certificates were performed using the study member's identification number which had been assigned at birth by the National Statistical Office. Trained recorders extracted the cause of death according to the International Classification of Diseases, Tenth Revision (suicide: ICD 10 E95, X60 to X84).[29]

Statistical analyses

We excluded 904 study participants who were deceased before 1 January 1993 (i.e. around the time of the baseline study) and a further 44 786 with missing information for BMI, alcohol intake, blood pressure, fasting blood glucose, or total cholesterol. We also dropped from analyses study members with an extremely low BMI ($<$15.0 kg/m^2), or short stature ($\leq$1.3 m). Additionally, we excluded 48 908 participants who reported having cancer, liver disease, CVD, or a respiratory disease at or prior to baseline survey. This resulted in an analytical sample of 1 234 927 individuals (445 022 women). The baseline characteristics of excluded study members relative to those in the analytical sample are given in *Table 1*. The difference in the characteristics between the groups, including the suicide rate, was marginal.

Where possible, individual risk factors were classified according to existing consensus grouping: blood pressure,[30] fasting blood cholesterol,[31] and BMI.[32] In our analyses, for consistency, the category with the lowest CVD risk was utilized as the referent. For those risk factors on a continuous scale, we also computed the relation between a standard deviation increase in value and suicide mortality risk.

Having first determined that the proportional hazards assumption had not been violated for each risk factor in relation to suicide mortality, we computed hazard ratios with accompanying 95% confidence intervals for men and women separately.[33] Initially, statistical models were adjusted for age. We then added a series of covariates to produce a multivariable-adjusted model. To investigate the possibility that severe mental illness at baseline examination had affected a given risk factor (e.g. BMI) and in turn influenced suicide risk, in additional analyses we excluded all suicide deaths occurring in the first 8 years of follow-up. All analyses were conducted using SAS, version 8.0 (SAS Institute Inc, Cary, NC, USA).

Results

In *Table 2*, we present the distribution of baseline characteristics of men and women in the whole sample, and according to suicide death status at follow-up. As anticipated, men generally had a less favourable CVD risk factor profile than women. This was most marked for smoking and alcohol intake, health behaviours which were virtually non-existent in Korean women. Comparing the unadjusted baseline characteristics of men and women who became suicide cases during follow-up vs. those that did not, there were generally marked differentials for blood cholesterol, smoking, marital status, and SES, although these were not always present for both genders. In total, there were 105 627 deaths from all causes arising during 14 years of follow-up, 472 (389 in men and 83 in women) of which were ascribed to suicide. As anticipated, there was a substantially greater rate of completed suicide in men than women (3.76 vs. 1.48 per 100 000 person-years).

Table 1 Baseline characteristics of study members included and excluded from the analytical sample—Korean Cancer Prevention Study

	Includees (*n* = 1 234 927)	Excludees (*n* = 94 598)
Age (year), mean (SD)	46.56 (11.60)	51.47 (11.89)
Body mass index (kg/m^2), mean (SD)	23.20 (2.79)	23.63 (3.41)
Alcohol intake (g/day), mean (SD)	11.14 (27.13)	8.64 (25.04)
Height (cm), mean (SD)	163.63 (8.57)	161.81 (9.08)
Systolic blood pressure (mmHg), mean (SD)	123.29 (17.18)	130.61 (22.17)
Diastolic blood pressure (mmHg), mean (SD)	79.93 (11.65)	83.79 (14.05)
Fasting blood cholesterol (mg/dL), mean (SD)	192.31 (38.40)	196.31 (41.16)
SES (insurance premium contribution, Won), mean (SD)	51 163 (38 604)	52 718 (41,625)
Male, % (*n*)	64	60
Smoking status, % (*n*)		
Never	47.08 (581 345)	48.45 (45829)
Former smoker	13.76 (169 887)	17.42 (16478)
Current smoker	39.17 (483 695)	34.13 (32291)
Exercise, % (*n*)		
Yes	24.25 (299 451)	22.39 (21182)
No	75.75 (935 476)	77.61 (73416)
Family history of CVD, % (*n*)		
Yes	16.13 (167 823)	22.89 (17094)
No	83.87 (872 900)	77.11 (57572)
Marital status, % (*n*)		
Married	93.59 (688 744)	94.32 (40716)
Not married	4.25 (31 282)	2.83 (1222)
Remarried, separate, divorce	2.16 (15 804)	2.85 (1228)
Suicide rate (100 000 person-years)	2.96	2.93
HR (95% CI)	1.0 (ref)	0.97 (0.68 - 1.38)

SES, Socioeconomic Status.

Table 3 depicts the relation of a series of biological indices with suicide mortality risk in men and women. There was little evidence of an association between either component of blood pressure (systolic and diastolic) and later suicide mortality. When these data were categorized according to the grade of hypertension, there was a suggestion of a modestly elevated risk of suicide in the stage 2 group, particularly in men, although statistical significance at conventional levels was not apparent. In men, low blood cholesterol was associated with an elevated risk of completed suicide, an effect that was stepwise across the classifications [*P*(trend) = 0.0015 in a multiple-adjusted model]. The comparable models for women revealed weaker effects.

Shorter men experienced a raised risk of suicide mortality, an association that was incremental across the stature groups (*P* trend = 0.0005), and unaffected when multiple confounders were taken into account. When we utilized height with weight to derive BMI, there was also a suggestion of elevated rates of suicide mortality among men who were considered underweight according to current guidelines for Asian populations. Although a linear trend was evident in these analyses (*P* for trend = 0.08 in fully-adjusted analyses), this appeared to be largely generated by the near-doubling of risk in underweight men and a modest reduction in risk in the obese rather than a clear stepwise effect across the BMI groups. Very similar results were apparent when World Health Organization categories[34] were utilized (results not shown but available upon request). For completed suicides in women, the effects of both height and BMI were in a similar direction to those apparent in men but generally weaker.

In *Table 4*, we summarize the relationships between a range of behavioural factors and suicide mortality rates. Relative to non-smokers, a markedly higher concentration of suicide deaths was seen among current smokers. This relationship was stepwise in women but not men, where being a former smoker appeared to confer no additional increase in risk above never smokers. In age-adjusted analyses, moderate daily intake of alcohol was also related to an increased rate of completed suicide; while the hazard ratio for completed suicide in the highest alcohol intake group was also raised, this was not statistically significant at conventional levels. There were too few women who regularly drank alcohol in the cohort to facilitate all analyses with suicide deaths; their low prevalence of smoking should also be considered

Table 2 Baseline characteristics of men and women in the whole sample and according to suicide death status at follow-up—Korean Cancer Prevention Study (n = 1 234 927 men and women)

	Men			Women		
	All (n = 789 905)	Suicide cases (n = 389)	Non-cases (n = 789 516)	All (n = 445 022)	Suicide cases (n = 83)	Non-cases (n = 444 939)
Age (year), mean (SD)	45.01 (11.03)	47.42 (10.42)	45.01 (11.03)	49.39 (12.08)	52.60 (12.11)	49.30 (12.07)
Body mass index (kg/m^2), mean (SD)	23.20 (2.57)	22.89 (2.60)	23.20 (2.57)	23.20 (3.14)	23.04 (3.03)	23.19 (3.14)
Alcohol intake (g/day), mean (SD)	17.28 (32.24)	16.62 (28.66)	17.31 (32.30)	0.18 (1.91)	0.26 (1.37)	0.18 (1.91)
Height (cm), mean (SD)	168.56 (5.43)	167.38 (5.46)	168.56 (5.42)	154.86 (5.66)	154.14 (5.57)	154.88 (5.66)
Systolic blood pressure (mmHg), mean (SD)	124.45 (15.95)	125.28 (16.88)	124.38 (15.91)	121.46 (19.14)	125.05 (19.86)	121.36 (19.08)
Diastolic blood pressure (mmHg), mean (SD)	80.99 (11.01)	81.46 (11.72)	80.95 (11.00)	78.16 (12.55)	80.34 (13.00)	78.12 (12.54)
Fasting blood cholesterol (mg/dL), mean (SD)	191.23 (37.83)	186.31 (34.93)	191.19 (37.83)	194.41 (39.38)	195.33 (37.43)	194.29 (39.32)
SES (insurance premium contribution, Won), mean (SD)	50 840 (38 837)	45 686 (28 725)	50 840 (38 841)	51 723 (38 191)	52 252 (31 265)	51 723 (38 192)
Smoking status, % (n)						
Never	20.72 (163 645)	15.68 (61)	20.72 (163 584)	93.86 (417 700)	85.54 (71)	93.86 (417 629)
Former smoker	20.34 (160 667)	14.40 (56)	20.34 (160 611)	2.07 (9220)	3.61 (3)	2.07 (9217)
Current smoker	58.94 (465 593)	69.92 (272)	58.94 (465 321)	4.07 (18 102)	10.84 (9)	4.07 (18 093)
Exercise, % (n)						
Yes	28.61 (225 957)	32.13 (125)	28.60 (225 832)	16.51 (73 494)	14.46 (12)	16.52 (73 482)
No	71.39 (563 948)	68.87 (264)	71.40 (563 684)	83.49 (371 528)	85.54 (71)	83.48 (371 457)
Family history of CVD, % (n)						
Yes	15.07 (101 448)	14.07 (47)	15.07 (101 401)	18.06 (66 375)	14.29 (9)	18.06 (66 366)
No	84.93 (571 736)	85.93 (287)	84.93 (571 449)	81.94 (301 164)	85.71 (54)	81.94 (301 110)
Marital status, % (n)						
Married	95.16 (588 424)	92.70 (254)	95.16 (588 170)	85.34 (100 320)	81.82 (9)	85.34 (100 311)
Not married	3.05 (18 841)	3.65 (10)	3.05 (18 831)	10.58 (12 441)	18.18 (2)	10.58 (12 439)
Remarried, separate, divorce	1.48 (9169)	3.65 (10)	1.48 (9159)	1.28 (1501)	0 (0)	1.28 (1501)
Widow	0.31 (1937)	0.00 (0)	0.31 (1937)	2.80 (3294)	0 (0)	2.80 (3294)

SES, Socioeconomic Status.

caveat in making judgements about the link between this behaviour and suicide risk. Exercise was unrelated to suicide risk in either gender.

We also computed effect estimates in the subgroup of study members with complete data for marital status and socioeconomic status. In men (n = 618 371; 357 suicide deaths), there was some evidence that being unmarried was associated with a raised risk of suicide after full adjustment, although confidence intervals included unity (hazard ratio; 95% confidence interval: 1.60; 0.83, 3.06). There were too few events to examine the marital status–suicide link in women. For socioeconomic status, men making a more modest financial contribution to the insurance scheme—and therefore with lower salary and fewer assets—experienced greater suicide rates. Thus, comparing the lowest quartile (<29 921 South Korean Won) with the highest (>62 640) was associated with around a 65% increase in the rate of completed suicide (1.65; 1.21, 2.24). There was no such relationship in women (<32469 South Korean Won vs. >63573: 0.89; 0.50, 1.61). When marital status and socioeconomic status were utilized as covariates, there was essentially no impact on the magnitude of the relation of the depicted biological, behavioural, and psychosocial factors with suicide death (results not shown but available upon request).

We explored the role, if any, of reverse causality in the above-described associations by excluding men and women who committed suicide in the first 8 years of follow-up. In these sub-group analyses based on 375 suicide deaths in 749 983 men (76 suicide deaths in 428 574 women), the associations were essentially the same as in the main analysis. Similarly, on controlling for family history of CVD which was available in a sub-group of study members (n = 1 067 025; 416 suicide deaths), the effect estimates were again unchanged.

Table 3 **Hazard ratios (95% confidence intervals) for the association of biological cardiovascular disease risk factors with suicide mortality—Korean Cancer Prevention Study (*n* = 1 234 927 men and women)**

	Men			Women		
	Number of deaths/ number of subjects	Age-adjusted	Fully-adjusted[a]	Number of deaths/ number of subjects	Age-adjusted	Fully-adjusted[a]
Blood pressure, SBP/DBP (mmHg)						
Normal (<120/<80)	83/178 959	1 (ref)	1	24/162 201	1 (ref)	1
Pre-hypertensive (120–139/80–89)	168/330 231	1.06 (0.82, 1.38)	1.11 (0.85, 1.45)	31/154 167	1.22 (0.71, 2.09)	1.27 (0.74, 2.18)
Stage 1 hypertension (140–159/90–99)	96/210 808	0.88 (0.66, 1.19)	0.95 (0.70, 1.28)	16/84 237	1.02 (0.53, 1.96)	1.11 (0.57, 2.14)
Stage 2 hypertension (≥160/≥100)	42/69 907	1.13 (0.78, 1.66)	1.23 (0.84, 1.81)	12/44 417	1.42 (0.69, 2.92)	1.59 (0.76, 3.32)
P-value for trend	–	0.8576	0.7407	–	0.5057	0.3270
Per one SD increase SBP	–	1.01 (0.92, 1.12)	1.04 (0.94, 1.15)	–	1.10 (0.89, 1.37)	1.15 (0.92, 1.42)
Per one SD increase DBP	–	1.00 (0.91, 1.11)	1.04 (0.93, 1.15)	–	1.10 (0.88, 1.36)	1.14 (0.92, 1.42)
Fasting blood cholesterol (mg/dL)						
Desirable (<200)	260/492 300	1 (ref)	1	45/263 369	1 (ref)	1
Borderline high (200–239)	103/217 749	0.83 (0.66, 1.04)	0.83 (0.66, 1.04)	28/126 399	1.12 (0.70, 1.81)	0.88 (0.71, 1.08)
High (≥240)	26/79 856	0.56 (0.37, 0.83)	0.54 (0.36, 0.80)	10/55 254	0.86 (0.43, 0.72)	0.59 (0.42, 0.84)
P-value for trend	–	0.0023	0.0015	–	0.8644	0.8254
Per one SD increase	–	0.83 (0.74, 0.92)	0.82 (0.74, 0.92)	–	0.93 (0.74, 1.17)	0.92 (0.73, 1.16)
Height (cm)						
Quartile 1	110/164 359	1.67 (1.22, 2.29)	1.68 (1.23, 2.30)	29/118 321	1.21 (0.63, 2.30)	1.18 (0.62, 2.26)
Quartile 2	111/212 824	1.29 (0.95, 1.75)	1.29 (0.95, 1.75)	18/116 196	0.85 (0.43, 1.65)	0.85 (0.43, 1.66)
Quartile 3	101/234 483	1.10 (0.81, 1.50)	1.10 (0.81, 1.50)	18/91 149	1.18 (0.61, 2.28)	1.18 (0.61, 2.29)
Quartile 4	67/178 239	1 (ref)	1	18/119 356	1 (ref)	1
P-value for trend	–	0.0005	0.0005	–	0.7659	0.8144
Per one SD increase	–	0.82 (0.74, 0.91)	0.82 (0.74, 0.91)	–	0.99 (0.78, 1.26)	1.00 (0.79, 1.27)
Body mass index (kg/m^2)						
Underweight (15–18.4)	17/18 467	2.10 (1.27, 3.47)	2.08 (1.26, 3.45)	6/21 653	1.70 (0.71, 4.05)	1.60 (0.67, 3.86)
Normal weight (18.5–22.9)	176/361 561	1 (ref)	1	37/202 983	1 (ref)	1
Overweight (23–24.9)	120/223 687	1.04 (0.82, 1.31)	1.08 (0.86, 1.37)	20/102 699	0.91 (0.52, 1.57)	0.90 (0.52, 1.56)
Obese (25+)	76/186 190	0.79 (0.60, 1.04)	0.85 (0.65, 1.12)	20/117 687	0.74 (0.42, 1.29)	0.70 (0.40, 1.24)
P-value for trend	–	0.0183	0.0842	–	0.1256	0.1055
Per one SD increase BMI	–	0.85 (0.77, 0.94)	0.87 (0.78, 0.97)	–	0.85 (0.67, 1.07)	0.83 (0.65, 1.05)

[a]Fully-adjusted model contains all covariates (except the exposure variable): age, smoking status, alcohol drinking, exercise, body mass index, height, blood pressure, blood cholesterol, and blood glucose. One SD for systolic blood pressure: 15.96 (men) and 19.15 mmHg (women); one SD for diastolic blood pressure: 11.02 (men) and 12.56 mmHg (women); one SD for fasting blood cholesterol: 37.83 (men) and 39.39 mg/dL (women). Quartiles for height: <165, 165–168, 169–172, ≥173 cm (men); <152, 152–155, 156–158, ≥159 cm (women). One SD for height: 5.47 cm (men) and 5.66 cm (women). One SD for BMI: 2.57 kg/m^2 (men) and 3.14 kg/m^2 (women).

Table 4 Hazard ratios (95% confidence intervals) for the association of behavioural cardiovascular disease risk factors with suicide mortality—Korean Cancer Prevention Study (n = 1 234 927 men and women)

	Men			Women		
	Number of deaths/number of subjects	Age-adjusted	Fully-adjusted[a]	Number of deaths/number of subjects	Age-adjusted	Fully-adjusted[a]
Smoking status						
Never	61/163 645	1 (ref)	1	71/417 700	1 (ref)	1
Former	56/160 667	0.91 (0.63, 1.30)	0.92 (0.64, 1.32)	3/9220	1.75 (0.54, 5.70)	1.52 (0.46, 4.97)
Current	272/465 593	1.67 (1.27, 2.21)	1.69 (1.27, 2.24)	9/18 102	2.74 (1.32, 5.68)	2.19 (1.03, 4.66)
P-value for trend	–	<0.0001	<0.0001	–	0.0057	0.0384
Alcohol intake (g/day)						
0	79/183 822	1 (ref)	1	63/381 376	1 (ref)	1
1–24	239/454 221	1.29 (1.00, 1.66)	1.20 (0.93, 1.56)	20/63 367	1.99 (1.20, 3.29)	1.83 (1.09, 3.07)
≥25	71/156 862	1.10 (0.80, 1.53)	0.99 (0.71, 1.38)	0/279	–[b]	–
P-value for trend	–	0.4821	0.9940	–	–	–
Per one SD increase	–	0.97 (0.87, 1.08)	0.95 (0.84, 1.06)	–	1.03 (0.93, 1.13)	1.02 (0.91, 1.13)
Exercise						
Yes	125/225 957	1.0 (ref)	1	12/73 494	1 (ref)	1
No	264/563 948	0.92 (0.74, 1.15)	0.86 (0.69, 1.07)	71/371528	1.21 (0.66, 2.24)	1.23 (0.66, 2.27)
P-value for difference	–	0.4679	0.1582	–	0.5359	0.5166

[a]Fully adjusted model contains all covariates except the exposure variable: age, smoking status, alcohol drinking, exercise, body mass index, height, blood pressure, blood cholesterol, and blood glucose. One SD alcohol consumption per day: 32.2 g (men) and 1.9 g (women).
[b]Insufficient numbers of deaths to compute hazard ratios.

Finally, we examined the influence of gender on suicide risk in the total cohort, in particular to explore if the well-documented higher rates of completed suicide in men was in part explained by their generally less favourable CVD risk factor profile relative to women (*Table 2*). In age-adjusted analyses, as expected, men experienced two and a half times the risk of suicide (2.67; 2.10, 3.40) relative to women. Controlling for a range of CVD risk factors lead to marked attenuation, although suicide rates in men remained higher (1.69; 1.19, 2.39).

Discussion

The main findings of the present analyses confirmed the expected associations of both alcohol intake and smoking with raised suicide mortality risk. Of the potential risk indices that have been less well documented, low blood cholesterol, reduced height, being underweight, being unmarried, and of lower socio-economic status were all related to an increased suicide risk, effects that largely held after statistical control and our attempts to take into account reverse causality. These associations were generally apparent in both genders, although the effects were weaker in women which may be ascribed to the lower statistical power in this group. The gender difference in suicide mortality—in the present study, and elsewhere,[1] men experience higher rates than women—was partially explained by the markedly less favourable CVD risk factor profile in men.

Blood cholesterol

Our finding of a relation between suicide risk and low blood cholesterol levels is consistent with the majority of the few prior studies conducted,[16–19] all of which are several orders of magnitude smaller in scale than our own. Plausible mechanisms linking blood cholesterol and completed suicide include the suggestion that lower cholesterol may be a proxy for serotonergic function,[35] with higher levels of serotonine plausibly responsible for suppression of symptoms of depression,[36,37] impulsive aggression,[38,39] and suicidal ideation.[40] The increasing evidence of an association of low cholesterol with suicide death has led to some calls for it to be included in predictive algorithms.[41]

Body mass index

Although little examined in women, a small series of studies of men indicate that those who are underweight typically experience a higher risk of suicide mortality relative to their normal weight counterparts,[21,22] although this is not a universal finding.[14,15] We also found some evidence of a gradient, although it was not incremental across the full BMI range of values. While this relationship is mechanistically consistent with the afore-described association of low blood cholesterol with suicide risk which may, as described, be explained by serotonin function, the BMI–suicide relationship herein was unaltered after adjustment for blood lipids.

Physical stature

A recent systematic review[42] identified a small group of studies that have examined the relation of height with completed suicide risk[21,43–45] and attempted episodes.[46] In general, there is a lower suicide rate in taller people. At least two explanations have been advanced for the stature–suicide link.[42] First, experience of psychosocial stress in early life may lead to stunting,[47] which in turn is linked to psychosis,[48] a psychiatric disorder that is itself a risk factor for suicide.[49,50] Secondly, intelligence has been linked to both height (positively)[51] and suicide risk (negatively).[52] It is possible that shorter individuals suffer victimization and they are less well equipped, cognitively and socially, to find alternative coping strategies when this does occur; thus, suicide appears to be the only viable option.[52]

Blood pressure

To our knowledge, only three studies[7,13,20] have examined the link between blood pressure and suicide rates. In cohort analyses based on a large randomized trial (the Multiple Risk Factor Intervention Trial, MRFIT), increased blood pressure was related to reduced mortality, although this effect was not incremental across the blood pressure categories.[13] In a smaller Finnish study, the reverse gradient was reported.[20] In the present analyses, in keeping with the findings of the Seven Countries Study,[7] we found no evidence of an association between blood pressure and suicide deaths.

Cigarette smoking and alcohol intake

Concordant with the results of other studies, we found that men and women who smoked cigarettes[4–9] and were heavier consumers of alcohol[10–12] experienced a markedly increased risk of suicide; associations that were little attenuated after statistical adjustment. The role, if any, of these behaviours, particularly cigarette smoking, in the aetiology of suicide remains contentious and much debated. Artefactual (non-causal) explanations include the suggestion that individuals with heavier intake of tobacco and alcohol are attempting to self-medicate as a treatment for their mental illness, such as depression, and this is generating an increased occurrence of suicide in these persons.[53] Some support has been found for this: in one study that controlled for mental illness, the smoking–suicide gradient was eliminated.[53] A causal counter argument is that smoking provokes mental illness rather than being a consequence of it, and adjustment for mental illness should not be made in this instance because it is a mediating variable.[54]

Study strengths and limitations

This study has several strengths including its size (the largest to date to explore risk factors for suicide mortality), its prospective cohort design, and its sample, which comprised Asians in a literature that is otherwise dominated by Caucasian cohorts. However, the study is not of course without its limitations. First, we did not have cohort-wide data on psychological health, particularly depression, which is a known risk factor for suicide.[1] However, selected studies do hold data on psychological health and, on controlling for it, its impact on the relationship between the aforedescribed risk factors and suicide mortality is mixed. Controlling for mental illness abolished the smoking–suicide gradient in Swedish men,[53] while in another Scandinavian cohort, the apparent increased risk of suicide mortality in the underweight was robust to the adjustment for psychological health.[21] Secondly, we did not have data on diet with which to assess the relationship with suicide risk. Given that possibility that higher serum cholesterol was related to lower suicide mortality risk, it would be of value to examine whether the same were true of dietary cholesterol. Finally, the use of an occupational cohort raises issues about generalizability of our findings. Owing to the healthy worker effect—the notion that employed individuals are healthier and have longer life expectancy that the general population by simple virtue of the fact they are sufficiently fit to participate in the labour market—the suicide rates in this cohort were markedly lower than for the total population of South Korea.[25] However, the doubling of suicide rates in men compared with women was still apparent. We do not think that the expected lower absolute rate of suicide in the present study is likely to impact on any risk factor–suicide relations we have reported.

In conclusion, in this large prospective cohort study of Asian men and women, in accordance with observations from Caucasian populations, we found that being unmarried, of lower socioeconomic status, smoking, alcohol intake, low blood cholesterol, lower height, and underweight were associated with an increased risk of completed suicide. This area of research warrants further examination.

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