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Socio-economic determinants of suicide: an ecological analysis of 35 countries

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Abstract
Purpose A long tradition of research has shown a relationship between suicide rates and socio-economic factors. However, most investigations have neglected to account for country-specific influences. The purpose of this study was to clarify the association between socio-economic variables and gender-specific suicide rates in 35 countries, using analytic techniques able to control for effects embedded within different country contexts.
Method Data relating to male and female age-standardised suicide rates (obtained from the WHO Statistical Information System) were analysed using fixed-effect regression. The possible associations between suicide rates and social variables were tested using data for 35 countries over the period 1980–2006.
Results Findings indicated that higher male and female suicide rates were associated with increased female labour force participation, unemployment, and the proportion of persons over 65 years. Reductions in male and female suicide rates were associated with increased health spending per capita. The study also revealed that higher fertility was associated with a reduction in male suicide. Female labour force participation had a stronger effect on male suicide rates.
Conclusions The results of this study suggest that variables related to the labour market and the economy were better explanatory factors of suicide rates than population-level indicators of interpersonal relationships. Although results were generally similar for males and females, males appeared to be more sensitive to changes in the social environment than women.

Keywords Social variables · Economic variables · Suicide · Ecological observations · Fixed-effect regression

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Introduction

Suicide rates are thought to be affected by societies, economies and cultures [1, 2]. This assumption has roots in the work of Durkheim [3], who argued that the suicide rate of a population (deaths per 100,000) was dependent on two societal forces called *social integration* and *social regulation*. Although neither of these concepts was explicitly defined in Durkheim's investigation of suicide, both have been used to understand the relationship between the structures, values and norms of a society and its corresponding population-level suicide rate. *Social integration* refers to the bonds and links that attach individuals to social groups outside of themselves [4, 5]. These bonds create a feeling of allegiance to the wider group (e.g. national identity or religious groups), and are manifested in devotion towards common goals and shared beliefs and sentiments. The second of Durkheim's concepts is *social regulation*, which refers to the mechanisms through which society imposes restraints and limits on individual needs (e.g., desires for wealth and power) and thereby prevents variations in the suicide rate of a population [5]. One of the best examples of social regulatory mechanisms is religious structures and groups, which can prevent suicide by promoting life-affirming beliefs that condemn suicidal behaviour [6].

A criticism of Durkheim's [3] framework is that it fails to operationally define concepts such as *social integration* and *social regulation* [7]. The close theoretical nature of the two concepts is a further limitation, as there appears to be some degree of overlap in the mechanisms promoting *social integration* and *regulation* [8]. These theoretical problems have hindered research into the validity of Durkheim's [3] argument about the underpinning "social causes" of suicide. However, beyond these criticisms, Durkheim [3] makes two major points that continue to be important in contemporary research on suicide. The first is that society influences individual predispositions for suicide: "the victim's acts which at first seem to express only his personal temperament are really the supplement and prolongation of a social condition which they express externally" [3, p. 299]. The second is that the collective rate of suicide (i.e., suicide deaths per 100,000) in a given group illustrates the geographical, cultural, social and economic characteristics of that society: "Each social group has a collective inclination for the act, quite its own." [3, p. 299].

Social-economic variables and the contextual effect on suicide mortality

The link between contextual factors (i.e. social, economic and cultural factors embedded in a society) and suicide rates has been investigated using numerous socio-economic variables. At a population level, fertility [9–11] and marriage rates [12, 13] have been found to be associated with lower suicide rates. A common conclusion of these findings is that stable social relationships (as in family and married persons) provide a protective influence against suicide. Conversely, the number of divorces in society is believed to represent a reduction in the strength of relationships [12–14]. The migration rate within a population has also been related to higher suicide rates [15–18]. A possible explanation for this adverse effect is that migration disrupts traditionally protective structures and support networks, creates greater community fragmentation and subsequently increases the risk of suicide [15, 16].

Aside from factors related to the strength of social connections and relationships, variables such as employment and health services have their own unique relationship to suicide mortality. For example, increased individual or household income has been associated with significantly lower suicide rates in several countries [19–21]. Stack [22] observed that financial security reduces stress and makes life more worthwhile, thus reducing the propensity toward suicide. Research also suggests that health care spending is related to lower rates of suicide [23–25], which may reflect improved attention to health and well-being in society and the greater possibility for suicide prevention initiatives. In comparison, unemployment is thought to increase suicide risk [26], both because job-loss violates the regular functioning of a society (based on the assumption that being employed in society is the norm, while being unemployed is not) and constitutes a loss of income [19, 27]. This may be particularly detrimental for males, for whom employment constitutes an important source of self-worth [28].

The association between suicide and socio-economic variables is also sensitive to changes in norms and values over time. As an illustration, up until the 1950s and 1960s, female-labour force participation in a population was thought to be associated with higher suicide rates, as female employment was considered a violation of social norms [29]. However, as female-labour force participation has become normal for high-income countries over the past couple of decades, its adverse effect on suicide rates disappeared [30, 31].

Researchers during the early 1900s in Europe argued that increasing literacy would be associated with high suicide rates, as education systems challenged the norms and protective values espoused by the Church [16]. The loss of traditionally protective influences, such as religion, was thought to then have flow-on effects to higher rates of suicide [16]. However, contrary to this, recent evidence suggests that education is related to lower suicide rates [32].

Evidence from spatial studies also demonstrates the dynamic nature of the relationship between contextual factors and suicide. For instance, on the basis of some empirical work in the 1950s, it has been argued that urban areas should have higher rates of suicide than rural areas [Sainsbury 1955, cited 33]. However, in many countries of the world, it now appears that the burden of rural suicide is far greater than suicide in urban localities (e.g. Asian countries in the Western Pacific, India and Australia) [34–37]. Some of the reasons for high suicide rates in rural areas include a lack of access to health services, lower incomes, greater availability of lethal means to suicide, and a high volume of migration from rural to urban areas [35, 38].

The research discussed above seems to support the link between contextual factors and suicide rates within populations. However, much of this past work has been based on the experience of high-income and western countries, while there is a comparatively limited understanding of the relationship between socio-economic variables and suicide in Asia, South America, East-Central Europe and the Baltic States. This lack of knowledge about the relationships between contextual factors and suicide is problematic considering the high and increasing burden of suicide in these areas of the world [39–41].

The aim of this study was to advance understanding about the socio-economic correlates of suicide in a large number of countries in the world, including some previously neglected in research. Unlike previous approaches, this study used an estimation technique sensitive to possible variations associated with differences over time and among countries. It also makes an effort to control for a wide range of factors that may influence the relationship between contextual factors and suicide.

Methodology

Sample

Two main criteria were used to select sample countries for this project. First, we examined the availability of suicide data on males and females among all countries that report information to WHO. We then selected those with data available for the socio-economic variables used in the study (see below).

The final sample included 35 countries, grouped into eight geographical-cultural (geo-cultural) regions of the world. The criteria for these geo-cultural groupings originated from the United Nations Group of Experts on Geographical Names (UNGEGN) [42] and from previous work in suicidology [43].

The geo-cultural regions and countries included in the study are East-Central Europe (Bulgaria, the Czech Republic, Hungary, Poland, the Russian Federation and Ukraine); the Baltic States (Estonia, Lithuania and Latvia); Western Europe (Austria, France, Germany, Slovenia and Switzerland); Southern Europe (Greece, Italy, Portugal and Spain); and Scandinavia (Denmark, Finland, Norway and Sweden). We also included some nations with Anglo-Saxon cultural heritage (Australia, New Zealand, Canada and the United Kingdom) and several South American countries (Brazil, Costa Rica, El Salvador, Mexico and Uruguay). Countries from Asia included China, Japan, Singapore and the Republic of Korea.

Data on intentional self-harm (as defined by the most recent International Classification for Disease-ICD-10) were obtained from the WHO Statistical Information System (WHOSIS). Gender-specific age-standardised suicide rates were calculated for all countries in the sample over the period 1980–2006 using population data available from WHO Statistical Information System (WHOSIS). Suicide rates were log-transformed to reduce possible heterogeneity in the error term and to offer a more simplistic interpretation of the estimated regression coefficients [44].

Socio-economic variables

There were a number of criteria used to select the socio-economic indicators used in the study. First, we only included variables that were available at the country-level. We verified the availability of these variables for the largest possible time frame, which proved to be the period 1980–2006. The data sources for variables were WHOSIS, the United Nations Data Service (UN Data), the World Development Indicators (WDI), the United Nations Educational Scientific and Cultural Organization Institute for Statistics (UNESCO) and the International Labour Organization.

As in past research, we sought to investigate the influence of variables such as health care (per capita health expenditure) and income (GDP per capita). Variables chosen to examine the influence of shifts in employment circumstances included unemployment (unemployment as a proportion of the total workforce) and agricultural employment (the proportion of employees in agriculture out of the total employed workforce). The latter variable was chosen to represent the possible influence of occupation on suicide [45]. The other ecological indicators in this study have also been used in previous research; we included them to re-assess their relationship with suicide rates in a different sample and time period. These were divorce (divorced persons as a proportion of the total population), fertility (the number of births per woman in the country), the rural population (persons living in rural areas as a proportion of the total population), international migrants (the proportion of overseas migrants in the total population) and female labour force participation (employed females as a proportion in the total employed workforce). The proportion of the population over 65 years was also included in the analytic model to evaluate the possible influence of the age-distribution on suicide rates.

Statistical approach

A least-square dummy variable (LSDV) fixed-effect model was used to control for country-specific effects on male and female age-standardised suicide rates. Fixed-effects models have been used in previous panel data investigations of suicide [20, 21, 46–49]. The advantage of this approach is that is can account for country-specific effects by treating them as fixed parameters. Consequently, fixed-effect models provide a substantial improvement on ordinary-least square regression techniques, which fail to account for unique individual differences within country clusters. These models were estimated using robust standard errors, which are relatively resistant to heteroskedasticity [50, 51].

The estimation models for these relationships are

$$\log(\mathrm{SR_{ti}}) = \beta_0 + \beta_1 X_{\mathrm{ti}} + \beta_3 c_{\mathrm{t}} + \beta_4 \mathrm{time}_i + \mu_{\mathrm{ti}} \quad (1)$$

where $\mathrm{SR_{ti}}$ is the age-standardised suicide rate for each country and year (calculated for males and females); X_{ti} is a vector of explanatory variables; c_{t} is the country-specific effect; $\mathrm{time_i}$ represents the 5-year time effects; and μ_{ti} is the residual term. β_0, β_1, β_2, β_3 and β_4 are the coefficients to be estimated. Five-year indicator variables (e.g. 1980–1984, 1985–1989, 1990–1994, 1995–1999, 2000–2004, 2005–2006) are represented by $\beta_4 \mathrm{time_i}$. The last time period only accounted for 2 years (e.g., 2005–2006) and represented the reference group.

The model regresses mean differenced values of the variables on suicide rates [e.g. (mean of $\beta_1 X_{\mathrm{ti}}$ − mean of X_{i}) onto (mean of $\mathrm{SR_{ti}}$ − mean of $\mathrm{SR_i}$)].

Variables were standardised to have a mean of '0' and a standard deviation of '1'. Linear interpolation was used to estimate values in variables with more than 10% of data missing (i.e., GDP per capita, fertility and unemployment). This technique imputes data based on the assumption of a linear development of the variable [52].

All analyses were conducted using Stata version 10.

Results

Table 1 shows the mean suicide rates from 1980 to 2006 in all countries of the sample ($n = 35$). The lowest female rate (Table 1) was in Mexico (0.9 per 100,000), while the highest was in Hungary (20.3 per 100,000). The lowest rate of male suicide (Table 1) was again identified in Mexico (4.5 per 100,000) and the highest rate of male suicide was in Lithuania (64.2 per 100,000).

We chose to present descriptive results within regions (rather than individual countries) in order to save space and provide an illustration of the geographical differences within the sample. The mean for each independent variable within the eight geo-cultural regions included in the study, and for the global sample of 35 countries, can be seen in Table 2. The inter-regional country variation is shown by the upper and lower confidence intervals for the mean of each variable. Descriptive results demonstrate the wide variations in some of the variables used in the study, such as for unemployment, which was markedly higher in the Baltic States and East-Central Europe, compared with countries of Asia. There were also variations in health care spending and income per capita, with countries in the Scandinavian, Western-European and Anglo-Saxon geo-cultural regions being wealthier than the Baltic States, East-Central Europe and South America. The proportion of divorce in the population (transformed into a rate of per 10,000 to ease interpretation) also differed between regions, with the lowest rate found in Southern Europe and the highest found in the Baltic States.

Table 1 Gender-specific age-standardised suicide rates, 35 countries, 1980–2006

Country	Male suicide rate (mean 1980–2006)	Female suicide rate (mean 1980–2006)
Australia	18.5	5.2
Austria	34.8	12.7
Brazil	5.4	1.7
Bulgaria	22.4	8.9
Canada	20.4	5.6
Republic of China	13.6	16.9
Costa Rica	9.4	1.7
Czech Republic	28.1	9.1
Denmark	31.9	16.5
El Salvador	13.7	5.8
Estonia	47.4	13.8
Finland	41.0	11.0
France	29.7	11.0
Germany	21.3	8.4
Greece	5.5	1.7
Hungary	58.1	20.3
Italy	11.4	4.2
Japan	26.2	12.7
Republic of Korea	16.5	7.0
Latvia	53.6	12.8
Lithuania	64.2	13.3
Mexico	4.5	0.9
New Zealand	18.9	5.8
Norway	19.8	6.8
Poland	23.1	4.4
Portugal	12.4	4.3
Russian Federation	59.9	12.3
Singapore	14.1	9.8
Slovenia	46.2	13.5
Spain	10.7	3.5
Sweden	23.2	9.8
Switzerland	31.9	12.9
United Kingdom	11.8	4.5
Ukraine	43.2	9.2
Uruguay	17.6	4.2

Source: the WHO Statistical Information System (*WHOSIS*)

Multi-collinearity was examined by investigating the Variance Inflation Factors (VIF) test (Table 3). This measures the impact of collinearity among the variables in a regression model. None of the scores exceeded the critical value of 3, which suggests that multi-collinearity was not a problem in our data set, although it should be noted that there is no agreed 'rule of thumb' regarding variance inflation factors [53].

Table 2 Mean, upper confidence interval and lower confidence interval for independent variables in eight regions, 1980–2006

	Divorce, (per 10,000 of pop.)	Rural pop. (% of total pop.)	Unemploy. (% total workforce)	Agri. workers (% labour market)	Female employ. (% labour market)	International migrant pop (% total pop.)	Fertility rate (births per woman)	Health spending per capita (US$)	GDP per capita ($US)	Pop. over 65 years (% of total pop.)
Baltic States $n = 3$ (mean)	31.7	31.8	9.62	10.6	48.9	4.4	1.6	$387.2	$3,914.6	13.4
(95% lower confidence interval 95% upper confidence interval)	(25.8, 37.6)	(29.9, 33.7)	(6.7, 12.6)	(1.93, 19.4)	(48.2, 49.6)	(2.6, 6.3)	(1.5, 1.8)	($318, $450)	($3349, $4,481)	(12.6, 14.2)
Asia $n = 4$ (mean)	20.1	26.7	3.33	11.6	40.2	4.5	1.6	$900.6	$16,683	8.6
(95% lower confidence interval 95% upper confidence interval)	(3.37, 36.9)	(1.2, 52.2)	(2.2, 4.5)	(6.5, 16.7)	(37.7, 42.7)	(2.7, 6.2)	(1.3, 1.8)	($59, $2,226)	($520, $28,169)	(5.3, 11.9)
South America $n = 5$ (mean)	10.8	30.4	6.6	14.7	35.3	0.8	3	$315.6	$4,034.1	6.5
(95% lower confidence interval 95% upper confidence interval)	(2.79, 18.9)	(18, 42.9)	(4.3, 9.0)	(5.5, 23.9)	(31.4, 39.3)	(0.0, 2.7)	(2.6, 3.3)	($218, $413)	($2,777, $5,291)	(3.8, 9.1)
East-Central Europe $n = 6$ (mean)	25.8	32.2	9.56	12.7	46.5	1.5	1.6	$402.4	$3,038.9	12.9
(95% lower confidence interval 95% upper confidence interval)	(14, 37.6)	(28.3, 36)	(6.9, 12.2)	(5.3, 20)	(45, 48.1)	(0.0, 4.2)	(1.5, 1.7)	($182, $622)	($1715, $4,362)	(11.8, 14)
Western Europe $n = 5$ (mean)	15.8	32.3	6.9	4.6	35.8	3	1.5	$3,143.8	$20,610.7	14.8
(95% lower confidence interval 95% upper confidence interval)	(8.2, 22.5)	(25, 39.6)	(4, 9.8)	(1.6, 7.6)	(22.5, 49.1)	(1.8, 4.2)	(1.3, 1.7)	($2,090, $4,198)	($15,211, $26.009)	(13.4, 16.2)
Anglo-Saxon $n = 4$ (mean)	20.8	16.8	6.92	4.7	43.4	4.2	1.8	$3,245.5	$20,820	12.5
(95% lower confidence interval 95% upper confidence interval)	(9.5, 32)	(12.1, 21.6)	(5.2, 8.6)	(2, 7.4)	(42.3, 44.5)	(0.0, 11.1)	(1.7, 2.0)	($1,772, $4,719)	($14,940, $26,670)	(10.8, 14.1)
Scandinavia $n = 4$ (mean)	23.9	24.1	5.77	5.3	46.2	1.78	1.7	$3,692.1	$26,056	15.5
(95% lower confidence interval 95% upper confidence interval)	(18.3, 29.7)	(14.4, 33.7)	(3.1, 8.5)	(3.1, 7.5)	(45.2, 47.2)	(0.0, 4.9)	(1.6, 1.9)	($2,522, $4,862)	($21,798, $30,314)	(14.2, 16.9)
Southern Europe $n = 4$ (mean)	9.4	30.44	9.24	15.8	38.5	1.8	1.5	$1,851.3	$11,351	14.8
(95% lower confidence interval 95% upper confidence interval)	(4.1, 14.7)	(27.6, 48.7)	(5.1, 13.4)	(10.4, 21.3)	(34.7, 42.4)	(0.1, 4.5)	(1.4, 1.6)	($1,457, $2,245)	($9,604, $13,098)	(14.2, 15.4)
Total sample ($n = 35$) (mean)	18.4	29	7.2	10	41.9	2	1.8	$1594.2	$13,290.6	12.4

Source: the United Nations Data Service (*UN Data*), the World Development Indicators (*WDI*), the United Nations Educational Scientific and Cultural Organization Institute for Statistics (*UNESCO*), and the International Labour Organization

Table 3 Variance inflation factors

	VIF	1/VIF
Divorce (% pop)	1.65	0.61
Rural population (% pop)	2.2	0.45
Unemployment (% pop)	1.31	0.76
Employment in agriculture (% employed pop)	1.14	0.87
Females in the labour force	2.07	0.48
International migrants (% pop)	1.02	0.98
Fertility rate (per female in the pop)	2.06	0.49
Expenditure on health (per capita)	2.74	0.36
Population over 65 years (% pop)	2.34	0.43
GDP per capita	1.4	0.71

As can be seen in Table 4, the fixed-effects analyses passed the F-test of significance for both males and females, which suggests that the estimated coefficients in the equation are jointly equal to zero. This result also supports the earlier point that fixed-effect regression models are a more appropriate choice for cross-country research than pooled ordinary-least-squared models, which fail to control for country-unique characteristics. For males, the "within" R^2 value was 0.3937 and the overall R^2 was 0.2244. For females, comparable goodness-of-fit statistics were 0.2881 and 0.2175 for the "within" and overall R^2, respectively. The R^2 was calculated on the regression of mean de-trended datasets and groups effects (estimated as fixed-effects).

The models indicate that male suicide was positively related to unemployment (coefficient = 0.03, $p < 0.05$), female participation in the work force (coefficient = 0.10, $p < 0.001$) and the proportion of the population over the age of 65 years (coefficient = 0.06, $p < 0.001$). This suggests that an increase in these variables was associated with an increase in male suicide. Expenditure on health (coefficient = −0.14, $p < 0.001$) and fertility (coefficient = −0.13, $p < 0.05$) were related to a reduction in male suicide. Variables associated with an increase in female suicide included unemployment (coefficient = 0.04, $p < 0.05$), female participation in the work force (coefficient = 0.07, $p < 0.05$) and the proportion of the population over the age of 65 years (coefficient = 0.06, $p < 0.05$). Expenditure on health (coefficient = −0.16, $p < 0.05$) was related to a reduction in suicide rates.

We then conducted analysis within the eight different geo-cultural regions to test for differential effects. This regression analysis focused on significant differences in health spending and employment. We have chosen not to display results in tabular form because the potentially

Table 4 The association between ecological risk and protective factors and male and female suicide, fixed-effects (using robust standard errors)

	Male suicide Fixed-effects model		Female suicide Fixed-effects model	
	Stand. coef.	Std. error	Stand. coef.	Std. error
Divorce (% pop)	0.02	0.02	0.01	0.02
Rural population (% pop)	0.03	0.03	−0.05	0.04
Unemployment (% pop)	0.03**	0.02	0.04**	0.02
Employment in agriculture (% employed pop)	0.01	0.02	0.03	0.02
Females in the labour force	0.10***	0.02	0.07**	0.03
International migrants (% pop)	0.01	0.00	−0.01	0.01
Fertility rate (per female in the pop)	−0.13**	0.06	−0.09	0.06
Expenditure on health (per capita)	−0.14***	0.03	−0.16**	0.05
Population over 65 years (% pop)	0.06***	0.01	0.06**	0.02
GDP per capita	−0.02	0.01	0.01	0.02
1980–1984	−0.06	0.10	0.16	0.12
1985–1989	0.01	0.09	0.14	0.11
1990–1994	−0.05	0.08	0.02	0.11
1995–1999	0.01	0.07	−0.01	0.08
2000–2004	−0.05	0.05	−0.05	0.06
Constant	2.37***	0.19	1.15***	0.24
R^2(within)	0.3937		0.2881	
R^2(overall)	0.2244		0.2175	
F(15,34)	13.63		4.48	
p value	<0.001		<0.001	

Dependent variable is age-standardised suicide rate (suicides per 100,000 inhabitants). *Stand. Coef.* refers to the Standardised Coefficient term. *Std. Error* refers to the robust standard error of the Standardised Coefficient term. Coefficients of period and country specific dummies not shown *** $p < 0.001$, ** $p < 0.05$

extensive nature of these results are outside the bounds of this paper and will be the subject of future research.

Results suggested that the association between unemployment and male suicide was significantly more noticeable in Anglo-Saxon countries, Scandinavia and South America than in the other regions. The effect of health spending was related to a more noticeable decrease in male suicide in Asia and East-Central Europe than other regions. The effect of health spending also differed for females and was associated with a greater decrease in suicide in Asia, the Baltic States, East-Central Europe and Scandinavia compared with other areas. These results indicate that the association between health and employment differed between the geo-cultural regions included in the study.

Discussion

This study examined the relationships between ten socio-economic variables and suicide rates in a diverse sample of countries. Aside from the inclusion of a considerable number of nations, the main contribution of this work was its ability to "control" for country-specific effects through the use of fixed-effect regression analysis.

Our results indicate that increased health spending over the period 1980–2006 was related to a reduction in male and female suicide rates. We might speculate that the greater allocation of resources to health over this period translated to more services available for suicidal persons, thus leading to a reduction in suicide rates [24, 25]. However, it is impossible to be definitive about the interpretation of this result, considering that this variable only provided an aggregate account of per capita health spending, without being specific about different types of health care services (e.g., GP services, mental health services, etc.). Also, as seen in the sensitivity analysis, the positive effect of health-spending appeared to be more apparent in the Asian and East-Central European regions than in the other areas of the sample. Although there may be a number of complex explanations for this finding, one possible interpretation is that increased spending on health care in Asia and East-Central Europe reflects wider and more appreciable improvements in the quality of life among the countries of these regions. Therefore, an overall growth in income and resources (such as health care) could be related to a decline in suicide rates. However, more country-specific analysis on the association between health spending and suicide is needed in order to validate this result.

Unemployment within populations was also seen to be important, and related to increased male and female rates. While the loss of a job may affect suicide by raising concerns about income, the damage it inflicts on self-perceived worth and esteem may also be influential [54]. This relationship was more apparent in Anglo-Saxon countries, Scandinavia and South America than the other geo-cultural regions included in the study. These differential effects suggest that the relationship between suicide and the conditions of employment—including the norms and expectations about jobs—differ between the regions included in the study. Regardless of geo-cultural differences, unemployment appeared to affect both women and men across the samples. This supports the argument that job loss represents an important variable in population-level suicide research [19, 26].

The results also identified higher male and female suicide rates in relation to the proportion of elderly subjects in the general population, which perhaps reflects the higher burden of suicide in older adults of the sample countries [39].

Although findings were generally similar for males and females, this paper revealed a number of gender differences in the relationship between socio-economic variables and suicide. For example, female labour force participation had a more observable effect on males, which may indicate that men are more influenced by changes in gender roles (e.g. the increasing number of females in paid employment) than women [10]. Male suicide was also affected by population-levels of fertility, which had no effect on female suicide rates. The finding that male suicide is more sensitive to macro-societal factors than female suicide concurs with past research [47, 55].

Other indicators representing social relationship and bonds, such as divorce and the migrant population, were not found to be significant. This may be because the meaning and value of romantic bonds—and the connection these have to suicidality—are embedded within the country context, rather than necessarily representing protective factors of universal impact. For instance, the societal value and expectations about marriage in Japan may be markedly different from other countries, such as Australia. If the value of social relationships differs between the countries included in this study, these cultural-effects would have been accounted for by the fixed effect regression, which controls for the influence of country-specific omitted variables. Similarly, the relationship between migration and suicide may also differ depending on the cultural, social and economic contexts within countries.

A limitation of this study was data availability, which restricted the sample size of the study and the type of the variables considered. Missing data on some variables were also a problem. We accounted for this, in part, by using linear interpolation, but acknowledge that there may be issues with this technique, particularly if the variables did not follow a linear path. Also, there may have been issues with our dependent variable, suicide, which may be influenced by death reporting practices and stigma against

suicide within countries [56, 57]. However, these biases are generally recognised to be stable over time, even when potential sources of bias in data recording are taken into account [57, 58]. This indicates that, although imperfect, population-level suicide data can provide a relatively stable reflection of the burden of suicide in the world. We must also draw attention to the small samples in the regional geo-cultural analysis (e.g., the Baltic States only had a sample size of three countries). Improved understanding of possible cultural differences between socio-economic variables and suicide rates would benefit from future research using a larger number of countries with better data quality. Like past ecological studies on suicide, a further problem could be the possible influence of unmeasured factors at the population level, such as mental illness, alcohol and drug use. The results may also be affected by variations due to time and country context, despite the use of a methodology sensitive to these problems.

Conclusions

Despite its limitations, this study confirms that socio-economic factors influence suicide, even after controlling for country context through the use of a fixed-effect regression analysis. The findings suggest that, globally, indicators related to health and the labour markets are more strongly related to suicide than other socio-economic variables. This study also found significant gender differences, with the participation of females in the workforce and fertility having a stronger impact on male suicide rates. The results of this study suggest the need for more cross-country research using appropriate and sensitive analytic techniques.

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