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Mini-Review

Comparing rates and patterns of male suicide and ''hidden suicide'' between nations and over time

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Abstract

Rates and age patterns of suicide differ between nations and population groups. The accuracy of data provided by national statistics offices has been questioned. This paper (1) compares recent high quality data regarding suicide rates in larger countries, and (2) explores differences between countries in proportions of male deaths coded as ''undetermined''. Data were obtained from the WHO Mortality Database regarding deaths in ten larger nations in 2015, coded (using ICD-10) as due to suicide, Event of Undetermined Intent (EUI), ill-defined or unknown cause (R99), or accidental poisoning or drowning. Numbers in 5-year age groups were recorded and rates calculated using population figures. Male suicide rates per 100,000 in the ten nations were found to vary between 8.40 (Mexico) and 37.52 (Korea). Most Western nations had bimodal male age patterns, US and Japan trimodal, and Korea's was upward-sloping. Male EUI rates varied: those in Mexico and Japan progressively increased across the age-range. The UK's male R99 cross-age rate was nearly zero; the other 9 countries had high rates, largely with exponential rises in late life. England & Wales publish combined suicide and EUI rates as their ''official'' suicide figures. Other countries, too, have been shown to code many suicides as ''undetermined deaths''. Partly this could be because of lack of resources to adequately investigate deaths. Accuracy of data would be improved by increased use of verbal autopsies. Comparisons of male age patterns of suicide, examining associations between period effects and sociocultural differences, could help identify reversible causative factors.

Keywords

Suicide; Undetermined deaths; Rates; Age patterns; Gender ratio

1. Introduction

Suicide is a worldwide phenomenon. Every year, about 800,000 persons die from suicide, the global annual mortality rate being estimated by the World Health Organization (WHO) as 10.7 per 100,000; the male : female ratio is 1.7 : 1. Upsettingly, 78% of completed suicides occur in low-and middle-income countries [1].

The chief aims of the current review are (1) to examine the availability and accuracy of suicide data provided by WHO, (2) to compare male suicide statistics (including gender ratios and differences from female rates) from several regions of the world, particularly noting male age patterns of suicide and whether rates and patterns differ from those reported in earlier studies, (3) to examine and compare male rates of deaths assigned to ICD-10 codes [2] that have been shown to be havens for "hidden suicides" (see below), and (4) to provoke discussion of reasons for differences between nations in reported rates and age patterns of male suicide and "hidden suicide". Exploring reasons for these differences can point to factors that may be contributing to suicide causation. Controlling such factors could be important preventative strategies.

Most nations provide data each year to the World Health Organization (WHO) regarding numbers of citizens who have died. Their statistics offices use the latest version of

the International Classification of Diseases (ICD-10) [2] to code the underlying cause of death in each case. Data are made available on-line in the WHO Mortality Database [3]. Until October, 2020, data concerning deaths in a majority of countries during the two preceding decades were provided in easily accessed tables; in 2020, data up to 2015 were available for most nations, while 2016 data were available for some. In 2021, access is less easy: the data can be obtained from the website only by those skilled in navigating the WHO system. However, statistical offices in some countries (e.g., Australia and Spain) publish their mortality data on-line, including (in early 2021) details of deaths up to 2019, though their most recently published data may still be subject to revision due to continuing legal processes in some cases [4].

Unfortunately, the accuracy of mortality data provided to WHO or on-line by over 60% of governments or national statistical offices, and recorded in WHO's Mortality Database, has been considered questionable or poor [5, 6]. Mikkelsen *et al.* [7] assessed the quality of cause-of-death data provided by nations around the world, and part of the assessment was a rating of the proportion of deaths assigned to entirely meaningless ICD-10 codes [2]. Of West European and South American nations, 73% and 42%, respectively, were assessed as providing very high quality mortality data, whereas all 6 South Asian nations were assessed as providing poor or very poor quality data [7]. An initial focus in the present article is on nations that provide mortality data deemed by Mikkelsen *et al.* [7] to be of very high quality.

Before exploring the data, it is appropriate to clarify what is commonly understood as the meanings of certain terms. "Suicide" means intentional self-killing, deliberately initiated, in expectation of a fatal outcome [8]. Where legal authorities find no recorded evidence of an intent to die, at the time the person initiated self-killing, or if it seems there was fluctuating or ambiguous intent [9], the death is coded as due to "Event of Undetermined Intent" (EUI; ICD-10 code Y10-Y34). The latter term was introduced to the ICD in 1968 and is assigned to external causes of death when the intention (to die or not) "cannot be established beyond reasonable doubt" by a medical or coronial examination [2]. This uncertainty is relatively common in cases of deaths caused by excessive doses of drugs or medication [10], especially if no suicide note or message was left [9, 11]. To an extent that varies between jurisdictions, there may be uncertainty in cases of drowning and falls from a height [10, 12]. Uncommonly (excepting in some countries), EUI may be the code assigned to deaths caused by gun discharge, single car accidents and other types of self-harm [3, 12, 13].

All deaths resulting from external causes (other than those attributable to infectious diseases) are called "unnatural deaths". They include those resulting from suicide, homicide, accident, medical error, acts of war and EUIs. Researchers writing about "undetermined deaths" have commonly used the term when referring just to EUI cases [14–16]. However, Pritchard *et al.* [17], referencing the WHO Mortality Database, wrote that, in addition to EUIs, certain types of accident (for example, those due to exposure to animate or inanimate mechanical forces, coded W20-64) could be called undetermined deaths if the decedent's intent was unclear. These authors did not mention that if there is good reason in such cases to be suspicious about the manner of death, the deaths could be coded Y33 (EUI, unspecified event); if not suspicious, they would be coded as accidents. They added that "undetermined deaths also include what are described as "inexplicable deaths""—including those where even a forensic autopsy gives no clue to causation. Notably, deaths coded *R99* (having ill-defined or unknown cause but categorized as natural deaths) are not called undetermined deaths.

In order to calculate suicide rates in different nations as accurately as possible it is important to estimate the degree to which suicides in those countries have been undercounted when compiling annual statistics. Suicide deaths that have been coded incorrectly can be called "hidden suicides" [18]. The most common ways in which suicides have been miscoded have been reported to be as (1) EUIs (coded Y10-34), (2) accidental deaths—most commonly accidental poisoning (coded X40-49), less often as accidental drowning (coded W65-74), or as another type of accident (for example, following gun discharge, in a car crash, falling from a height, or in a fire), and (3) ill-defined or unknown cause deaths (coded R99).

2. Method

Most of the data used in this study of mortality rates were taken from the WHO Mortality Database [3] during 2020. Because data obtained are in the public domain, ethical approval for this review was not sought. To calculate suicide rates in 2015 (or in other years), the total numbers of suicides during the year (male and female separately) in selected nations were noted, as were the numbers of suicides in each 5-year age group from 10–14 up to 80–84 years, plus 85+ years. Population figures (totals and in age groups) in 2015 were obtained on-line from Population Pyramid [19], and death rates per 100,000 were calculated. Rates of suicide by poisoning were calculated. Calculations made regarding suicide rates in previous years are not shown in this paper, except for some reported in previous studies.

The nations selected for initial review had populations larger than ten million, had reported all deaths registered there in 2015 together with assigned ICD-10 codes showing cause of death, and fulfilled criteria used by Mikkelsen *et al.* [7] when assessing mortality data as being of "very high quality". Three other nations with large populations (Cuba, Romania and the Czech Republic) also fulfilled these criteria but their data were omitted in order to ensure clarity of graphical presentation. The aim was to compare male suicide rates and age patterns in "Western" (English-speaking, other American and Western European) and "Eastern" (Asian) nations. At the time of this review, 2015 data were not available from Canada and France. Data from Eastern Mediterranean, African and South Asian nations (including India and Sri Lanka), and most East and South-East Asian nations and other countries were either not available, or did not satisfy population size or other criteria for selection. However, gender ratios and some

mortality data were obtained in relation to various other larger nations.

Rates of EUI, R99 and accidental poisoning and drowning deaths in the selected nations were calculated.

3. Results

3.1 Rates, gender ratios and age patterns of suicide

3.1.1 Comparison of national suicide rates and gender ratios

Table 1 shows male and female suicide rates in the 10 selected nations: male rates ranged between 2.2 and 4 times the rates of female suicide, the gender ratios being lowest in Korea, Japan and the Netherlands. Data for 2015 from WHO's Database show high gender ratios in Eastern Europe (e.g., 5.8 : 1 in Russia and Lithuania, and 6.7 : 1 in Poland and Latvia), while the mean gender ratio in Europe was 3.7 : 1. The ratios in China, Bangladesh and Pakistan were close to 1 : 1. Gender ratios in other South, Eastern and South-East Asian nations ranged between 1.7 (India) and 3.0.

Among the 10 selected nations, both male and female suicide rates were highest in Korea and Japan. Male rates were relatively high in the United States (US), Australia and Germany, but with the corresponding female rates relatively low. Among the 10, male rates were lowest in Mexico, Spain and England & Wales. Of the 191 nations with suicide and total death rates documented by WHO for 2015, 67 (35%) reported that less than 1% of all deaths were by suicide, including the UK and Spain (0.95%), Romania (0.93%) and 60% of the 52 African nations. In 6 (3%) of the 191 nations, it was reported that less than 0.5% of all deaths were by suicide; they included a Caribbean and two African nations, and Indonesia (0.49%), Greece (0.47%), and Syria (0.37%).

3.1.2 Age patterns of male suicide in 10 selected nations

Figs. 1,2 show the age patterns of male suicide in 4 European and 6 non-European nations. Four Western Europe patterns (and Australia's) were bimodal, but with differing suicide rates in late old age. The graph of Korea's pattern (Fig. 2) rose steeply in late life to a peak of 178 at 85+ years; rates at 75+ years are not graphed. The Japan, US and Chile age patterns appear to have been relatively flat but with peaks at age 20–24 years, 50–54 years and in late life (Fig. 2). Mexico's age patterns showed an early peak but then fell; the graph was relatively flat across to late life, when it sloped upwards a little.

3.2 Rates and age patterns of EUI deaths

As indicated in Table 1, the average EUI rate (male + female) per 100,000 in the 10 countries was about one seventh of the suicide rate. Rates varied from zero or near zero (in Chile, Spain and the Netherlands) to a rate of 3.53 (Korea). In England & Wales, where the rate of deaths coded (ICD-10) as suicides was 7.14, the EUI rate in 2015 was 1.97 (male 2.77, female 1.19), and the "officially" published suicide rate

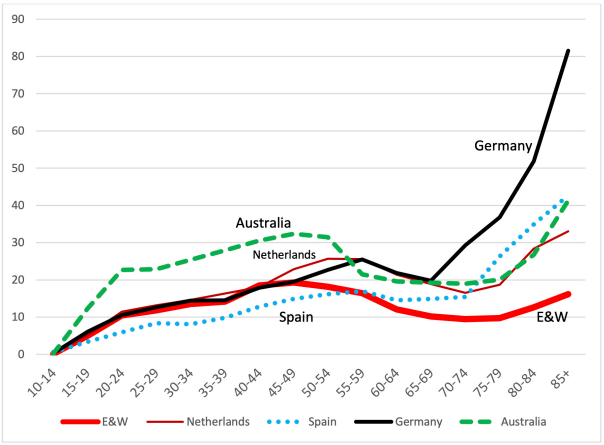

FIG. 1. Age patterns of male suicide rates in European nations and Australia in 2015#.

The England & Wales graph is of the age-group rates of male suicide reported to WHO. Its "official suicide rates" are the combined totals of suicide and EUI rates (not shown here).

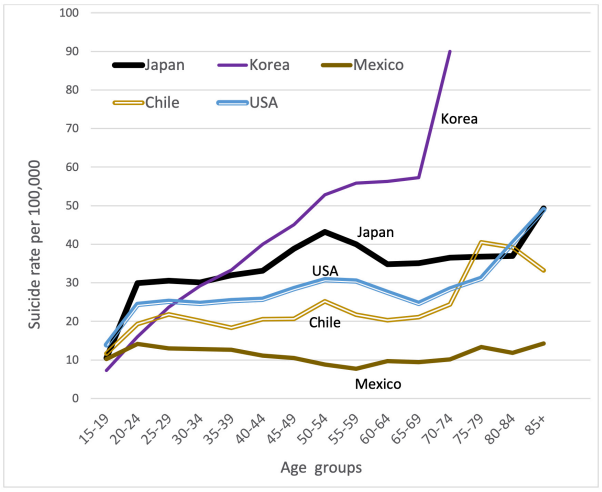

FIG. 2. Age patterns of male suicide rates in selected non-European nations in 2015#.

Rates of suicide at age 75–79, 80–84 and 85+ years in Korea have been omitted from the Figure: the rate at 85+ years was 178 per 100,000.

was 9.11 (i.e., 7.14 + 1.97). Fig. 3 compares male age patterns of EUI death rates between seven of the countries. Graphs of the age patterns of Korea's male suicide and EUI rates resemble each other, the EUI rate rising to 84 (nearly half the suicide rate) at age 85+ years. Japan's graph of EUI death rates was also upward-sloping, in contrast to its trimodal age pattern of suicides. Germany's age pattern of male EUI death rates was flat until rising to 4.1 at 75–79 years. The UK's male EUI age pattern was bimodal, peaking at 4.8 at age 30–34, falling below 2.0 in late life, but reaching 4.1 at 85+ years; the peak male suicide rate was at 40–49 years (Fig. 1). Fig. 3 shows the relatively low male EUI death rates in the US and Australia, being lowest (like in the UK) at age 70–84 years. Comparison of graphs in Figs. 1,2 versus 3 shows some similarity of the age patterns of male suicide and EUI

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deaths (UK, US and Australia), but with the earlier peaks about a decade younger in the EUI graphs. Korea's male suicide and EUI age patterns were similar, but similarities between the suicide and EUI male age patterns of the other nations varied from modest to absent. There was a striking difference between Mexico's initially downward-sloping and then relatively unchanging male age pattern of suicide, and its upward-sloping EUI graph.

Female EUI death rates in the seven countries were lower than the male rates, but male and female age patterns resembled each other; in the UK, US and Australia, the peaks were in middle age and relatively low, whereas in Korea, Japan, Mexico and Germany, peak female EUI rates were in late life.

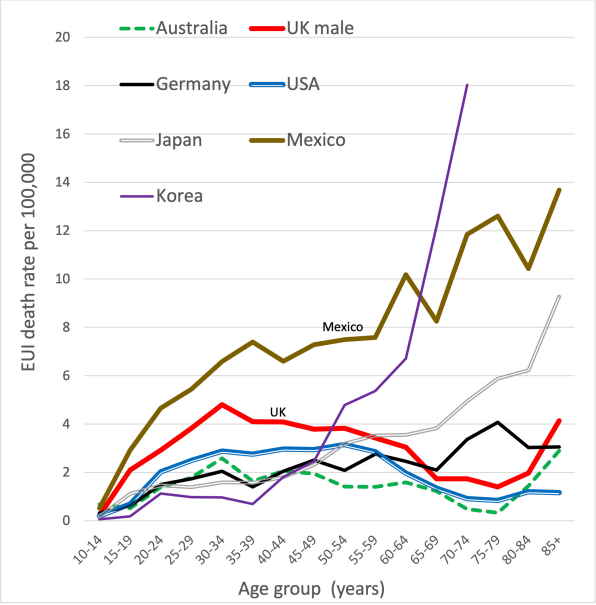

FIG. 3. Age patterns of male EUI rates in 2015*#.

* Ungraphed male EUI rates of the Netherlands, Spain and Chile were low or zero in 2015.

Korea rates at age 75–79, 80–84 and 85+ are not displayed in the above graph.

3.3 R99 rates and age patterns

R99 (ill-defined or unknown cause of death) rates in 2015 were higher than the corresponding suicide rates in 3 of the 10 countries (Table 1). Fig. 4 shows the age patterns of the male R99 rates in the 10 countries in 2015. All except that for the UK (with a late life rate of 5.4) show upward-sloping graphs. The US male R99 rate rose to about 35 in late life. Rates in Australia and Japan increased from middle age to reach about 50 at age 85+ years. Graphs of the other 6 nations show exponential rate increases, reaching about 100 (Mexico), 120 (Spain), and 150 to 275 (the Netherlands, Germany, Korea and Chile). The female age patterns of R99 deaths were all similar to the male patterns, the male rates being somewhat higher.

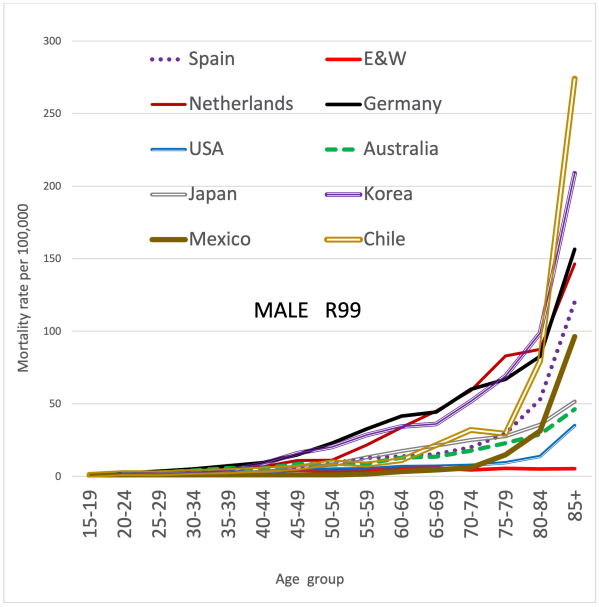

FIG. 4. Age patterns of male R99 rates in 2015.

3.4 Accidental poisoning and drowning rates

Contrastingly, the accidental poisoning rate was much lower than the suicide rate in most of the 10 countries and was less than 1.0 in half of them (Table 1). However, it was 5.01 in Australia. In England & Wales it was 5.87, peak rates being at age 40–44 years (male 21.54, female 7.24). The US accidental poisoning rate was even higher (14.84; male 20.0, female 9.8) and exceeded the suicide rate.

Accidental drowning was reportedly less common than accidental poisoning in 8 of the countries. In Spain, accidental poisoning reached peaks (both genders) at age 45–49 years (male 5.30 per 100,000) but was lower in older age groups up to late old age; contrastingly, accidental drowning rates in Spain were low until middle age, but then escalated exponentially in late life, male rates exceeding female. In England & Wales peak accidental poisoning rates were at age 35–44 years (male 21.0, female 6.75); the peak accidental drowning rate was at age 85+ years (male 0.93, female 0.40). In the US, Australia, Chile, Mexico, Germany and the Netherlands, rates of accidental poisoning were 2 to 15 times higher than accidental drowning rates. Contrastingly, in Japan (rate 3.49) and Korea (1.28), accidental drowning was much commoner than accidental poisoning (0.49 and 0.42); drowning suicide rates were 0.42 and 0.96, while drowning EUI rates were 0.44 and 0.56.

4. Discussion

4.1 Availability and accuracy of suicide data

The accuracy of suicide statistics needs to be assured if comparisons of national data are to be meaningful. The first aim of this review has been to explore the availability and accuracy of suicide data from around the world. WHO's Mortality Database has provided statistics regarding suicides in 2015

TABLE 1. Rates in 2015 of suicide and deaths assigned to ICD-10 "havens" for hidden suicides.

Nation	Suicide rate (M + F) per 100,000	Male suicide rate per 100,000	Female rate per 100,000	Gender ratio	Suicides % of all deaths	EUI	R99 rate (M & F) per 100,000	Accidental poisoning death rate (M + F) per 100,000
Korea	26.61	37.52	15.64	2.4	4.9	M 4.53 *F 2.53*	M 15.37 *F 7.49*	0.42
Japan	20.42	29.59	11.66	2.4	2	M 2.79 *F 1.44*	M 10.58 *F 5.66*	0.49
US	13.94	21.99	6.07	3.6	1.7	M 1.90 *F 1.16*	M 4.32 *F 3.23*	14.84 (M 20.01)
Australia	13	19.69	6.39	3	1.9	M 1.31 *F 0.68*	M 7.40 *F 5.05*	5.01
Germany	12.31	18.37	6.45	2.8	1.1	M 2.04 *F 1.19*	M 23.22 *F 14.98*	0.86
Holland	11.03	15.18	6.94	2.2	1.3	M 0.24 *F 0.16*	M18.40 *F 11.49*	0.98
Chile	10.22	16.48	4.14	3.9	1.8	0	M 8.03 *F 7.49*	1.36
Spain	7.72	11.69	3.88	2.9	0.9	M 0.15 *F 0.03*	M 9.78 *F 7.54*	1.81
England & Wales	7.14	11.02	3.36	3.3	0.8	M 2.77 *F 1.19*	M 2.81 *F 1.37*	5.87
Mexico	5.13	8.4	2	4	1	M 4.91 *F 1.02*	M 1.60 *F 1.38*	0.98
All 10 nations	13.19	20.21	6.49		1.6	M 2.55 *F 1.14*	M 7.92 *F 3.88*	

Source: WHO Mortality Database.

(and a number of previous years) in most nations of the world [3]. Limited data from 2016 were also made available. Examination of these data in late 2020, and of online mortality statistics provided by certain nations in relation to more recent deaths [20–22], has allowed exploration of differences between countries in their rates and patterns of suicide. However, what has become clear from the present review, and has been highlighted by various researchers [5, 7, 13], is that although relatively up-to-date suicide data are available in relation to most of the world's nations, there is considerable doubt about their accuracy. In particular, WHO and Global Burden of Disease (GBD) researchers have pointed to inappropriate coding of causes of death in many countries. The present article has shown that, even among nations that report very high quality mortality data [7], there is considerable variation between them in use of ICD-10 codes to record manner and cause of death (Table 1 and Figs. 3,4.

In 2016, 44% of the world's suicides occurred in India and China [13]. At that time, the number of suicides reported to WHO by India was 133,623 [23], but the GBD study estimated there had been 230,314 suicides in India [24]. The accuracy of suicide data reported by China has reportedly improved, though in 2014 such data were available from only 24% of the population [25]; data were unavailable from more than half the regions of that country [26].

4.2 Comparing suicide rates and age patterns in different regions of the world

The second aim of this review was to compare rates and age patterns of male suicide around the world, and to examine whether differences between the various nations could point to factors that affect causation of suicide. For example, if peak suicide rates are in late life in some jurisdictions but in middle age in others, explanations need to be sought. Are they related to period effects, cohort effects or what?

Previous studies have provided evidence of differences between patterns of suicide rates in East Asian and Western nations [21]. Gender ratios are higher in the West, and this has been partly attributed to Western male individualism and lower social integration of males. Male age patterns in Western nations have largely changed in the last few decades from upward-sloping to bimodal, with middle-age and late life peaks; in East Asia they are mainly upward-sloping, with high late life rates, though Japan's age pattern has progressively changed to be more like that of the US. Suicide rates are generally higher in East Asia than in the West. Suicide is more common among married people in East Asia, but not in the West. Suicide is more commonly attributed to mental illness in the West than in East Asia; researchers suggest that sociocultural factors are of prime importance in causation of East Asian suicide [27]. The recent decline in the suicide rate of younger women in China (and consequent increase in the gender ratio) has been attributed to urbanization: large numbers of young rural women have migrated to cities, thus removing themselves from feelings of being in a subordinate position in their family and from easy (commonly impulsive) access to pesticides [27, 28].

The present review demonstrates that suicide rates in Japan and Korea (male, female and total) in 2015 were considerably higher than the rates in the other eight nations listed in Table 1, and the gender ratios (male : female) were lower than those of the other nations, excepting the Netherlands. Although Japan and Korea are both East Asian nations, caution is needed before arguing that the difference between their suicide rates and the lower rates of the other eight nations provides further evidence of distinctive Eastern and Western patterns of suicide. Japan and Korea had higher suicide rates than most other East and South East Asian nations that report mortality statistics to WHO [3]; male suicide rates among the 16 nations in 2015 ranged from 5.2 (Philippines and Indonesia) to 20.5 (Japan), 21.4 (Thailand), 23.3 (Mongolia) and 29.6 (Korea) [29]. Mikkelsen *et al.* [7] assessed mortality data provided to WHO by the 16 nations as being very high in Japan and Korea, high in Singapore and Malaysia, medium in Taiwan and Thailand, and poor or very poor in the other 10. A major reason why Mikkelsen *et al.* [7] assessed quality of data as poor was the high proportion of deaths labelled as being of undetermined cause or intent. There is good reason to conduct research to uncover the true suicide rates in all these countries. It may be that some of the 16 nations do not conform to a so-called "Eastern pattern". It should also be noted that the gender ratio was less than 3.0 in only 8 of the 16 nations, which is again contrary to proposals about an Eastern pattern of suicide; the ratio was over 4 : 1 in three of the nations (Thailand 4.36, Myanmar 4.82 and Mongolia 5.38) [29].

Examination of male suicide patterns is largely confined here to the 10 larger nations with relatively up-to-date high quality mortality statistics. However, the above discussion, and Fig. 3,4, have highlighted considerable evidence of imprecise coding of cause of death, even in 10 countries with data quality assessed as very high.

In relation to suicide rates and age patterns, the data presented in this paper provoke questions. Firstly, why are male suicide rates much higher in Korea and Japan than in the European and American countries listed in Table 1? Male and female rates more than doubled in Korea between the 1990s and 2010s; rates in late life trebled [30]. This suicide increase was partly attributable to new awareness by people contemplating self-killing that charcoal-burning is a painless method of suicide. Reduced misclassification of suicides as accidents contributed to the change in reported rates [16]. However, most of the increase has been attributed to sociocultural factors. Park [31] believes that Korean society has shown collective cultural ambivalence, with Confucian ideals perceived by many as out-of-date. So-called modernization in East Asian countries has caused a social and economic transition that has reportedly led to broken family ties, and changes from extended to nuclear family structures [32]. Added to this, economic factors following Asian and Global Financial Crises appear to have precipitated a progressive increase in suicides [33].

In the 1960s, Japan had a bimodal male age pattern, with

a peak suicide rate of 24.3 at age 25–29, and, from middle age, an upward-sloping graph to a peak of 95.1 at age 85+ years. By the 1980s the pattern was trimodal, with a newly emerged middle-age peak (38.7); the latter rose to 70 in 1999–2003, following an Asian financial crisis [21]. Female rates did not rise. The age pattern in 2015 is shown in Fig. 2. As in Western countries, where there were comparable middle-age peaks in male suicide rates in 2015, the peak has been partly attributed to consequences of unemployment and financial losses, including feelings of shame about not fulfilling what they were perceiving as a "breadwinner" role [27]. The bimodal male age patterns documented in various Western European nations, Canada, Australia and New Zealand resulted from having peak rates at about 45–59 years, lower rates at about 60–79 years, and peak rates at 80+ years; Japan's trimodal age pattern was similar to that of the US, and very different to what it had been during earlier decades.

China and other East Asian nations (excepting Japan) have retained upward-sloping male patterns of suicide, without developing middle-age peaks in recent years [21, 27]. Late life rates have substantially decreased over recent decades (except in Korea) but so have rates of middle-aged groups. Chile had a more uniform (flat) male age pattern in 2015, with increases in late life, while Mexico's was downward-sloping across to middle age. Age patterns in South Asia, the Eastern Mediterranean and Eastern European nations have not been discussed in this review, but there is good reason to examine them (if reliable data can be obtained), to assess how they differ from those already discussed.

4.3 Hidden suicides

The third aim of this review has been to examine and compare, between the ten nations, rates of deaths coded to categories regarded as "havens" for hidden suicides. Although it is said that, globally, about 800,000 persons per year purposely kill themselves, there is widespread agreement that the true figure is unknown; suicides are undercounted [5]. It is recognized that some people who die by suicide take steps to ensure that their deaths are not identified as suicides and that families also (and even those who certify deaths) may conceal evidence about cause of death. This is understandable in countries where suicide is still a crime, or where religious or other reasons (e.g., insurance clauses) result in efforts at concealment. This could account for lower reported suicide rates in, for example, various Islamic countries [34].

The resources available to investigate deaths that have no clearly identifiable (and certifiable) cause vary between jurisdictions. Ideally, all such cases should be subject to verbal or psychological autopsy [35], with or without forensic autopsy and toxicology testing. Nations have been assessed regarding the frequency of mis-coding of deaths [36, 37]. WHO has used the term "garbage codes" (GCs) when referring to inappropriate use of ICD-10 codes that do not reveal the underlying cause of death, and WHO [2] includes the EUI codes (Y10-34) and R99 (ill-defined or unknown cause of death) among these GCs.

In England, Linsley *et al.* [38] noted "marked similarities" between cases where the coroner's verdict was suicide and those given an "open verdict", and concluded that most open verdict deaths in England should be included in studies of suicide. Following corroborative research, England & Wales now adds suicide and EUI death rate numbers, and the combined totals are issued as their "official" numbers of suicides per year. However, these official totals do not include other "hidden suicides", such as cases misclassified as accidents or R99 deaths, and an unknowable percentage of suicides misclassified as heart attacks or cases of "natural death". Review of Figs. 1,3 (above) shows that the age patterns of male suicide and EUI deaths in England & Wales in 2015 were both bimodal, but with the EUI peak at age 30–34 years and the suicide peak at 40–49 years. Thus the patterns differ somewhat. Researchers in Taiwan, Finland and Canada have shown that age patterns of their EUI death rates resemble those of suicide [18, 39, 40].

In nations where the demographic profiles of suicides and EUI deaths have been shown to be similar, there is reason to believe that most of their EUI deaths probably were suicides [18]. When they are dissimilar, maybe it is because (in relation to EUI deaths) absence of evidence of intent is associated with differences in age. In some countries, EUI death rates increase across the age range and in some they decrease, and review of the graphs in the present study shows that suicide and EUI death age patterns commonly differ—to a varying degree. There is good reason to conduct further research. To increase accuracy in identifying which EUI deaths were in fact suicides, verbal autopsies could be undertaken.

Examination of Figs. 2,3 together makes it seem possible that the relatively low male suicide rate in Mexico in 2015 may be partly accounted for by relatively high EUI rates (some suicides having been coded as EUI deaths), with a progressive increase across the age range to a rate of over 12 at 70+ years. However, and in contrast, the fact that male R99 rates are low in Mexico except in very late life makes it seem unlikely that many Mexican suicides are "hidden" as R99 deaths. Examination of Fig. 4 and R99 details in Table 1 makes it seem plausible that a majority of R99 deaths in most countries are attributable to difficulty in making definite diagnoses regarding deaths of very elderly persons—as intimated by Bakst *et al.* [41], who estimated (in Tel Aviv) that about 2% of R99 deaths were suicides. However, because the numbers of R99 deaths in many countries are large, even 2% could be a lot of suicides. As a striking exception, the R99 death rate in England & Wales was relatively low across the whole adult age range, so there is little likelihood that many suicides in England & Wales are concealed as R99 deaths.

A proportion of the "accidental poisoning" deaths (Table 1) could have been suicides. In Ontario, 64% of EUI deaths resulted from poisoning [40]. Oquendo and Volkow [42] cite evidence that suggests the true proportion of suicides among opioid-overdose deaths in the US is between 20% and 30%. Others have pointed to difficulties in differentiating accidental from intentional deaths among those who use/abuse drugs, "when the complex intent of these deaths may fall along a continuum between purely intentional and

unintentional" [43] (pp. 410). Surprisingly, in spite of the huge increase in opioid deaths in the US and Canada, online Canadian data show a decrease in poisoning suicides in the last few years.

It is likely that substantial proportions of drowning deaths in some countries have been suicides. If there is nothing (for example, a note) to indicate that a drowned person intended to drown, the death will be declared an accident. The 10 nations listed in Table 1 were among 32 OECD countries included in a study of drowning mortality [44]; this showed variability between nations in drowning-related certification processes.

The proportion of all deaths that were suicides in 10 nations that provided high quality mortality data in 2015 (especially if EUI deaths are added in, as in England & Wales) was well over 1% (Table 1). In countries with high infectious disease mortality rates the percentage of suicides among all deaths is understandably low (as in much of Africa), but in some nations (such as Greece and Italy), low percentages should foster caution when examining their suicide rates.

4.4 Causation of male suicide. How can rates be reduced?

The fourth aim of this review has been to provoke discussion of reasons for the differences between nations in their rates and age patterns of suicide and hidden suicide. Rates of male suicide have been at their highest in late life in most countries over the decades. However, reasons for the substantial and progressive decreases in male late life suicide rates in various nations, notably Australia, New Zealand, Japan and China, in the last 50 years [20, 45], should be considered. Possibilities include improved treatment of depression and of physical illnesses, and increased attention to the welfare of old or disabled persons. Nevertheless, male suicide rates still reach their highest peak at 85+ years in 8 of the 10 nations listed in Table 1 (the exceptions being England & Wales and Chile). There is some evidence that a significantly increased proportion of suicides in very late life could be called "rational" [46], some being "altruistic", aiming to lessen burdens on others.

This leads back to the question of suicide causation. Suicide in Asia is less often attributed to mental disorder than it is in the West. In a psychological autopsy study in China, 63% of suicide decedents were reported to have had mental disorders, two thirds being mood disorders [47]. In the West, over 90% of suicide decedents were said to have had mental disorders, though the findings were questioned [48]. Undoubtedly, melancholic depression can lead to suicide, but in rural China, Tong and Phillips found that psychosocial stress and social isolation, rather than psychiatric morbidity, were deemed to be the predominant risk factors for suicide [47]. Chen *et al.* [28] declared that, in Asia, life stresses (such as job loss, gambling, financial security issues and family conflicts) are the major factors leading to suicide.

There is good reason for suspecting that psychache (anguish, emotional turmoil, mental perturbation) precedes most suicides and that this arises from a complex interplay of factors [49]. Customs, beliefs and attitudes within a jurisdiction affect life satisfaction. Religious beliefs may help protect against suicide, as may a sense of connectedness and support from family or a community. Living in an extended family (more common in Asian than in English-speaking countries) could be protective. People and (to some extent) sociocultural groups vary in how they react to situations. Combinations of circumstances may determine whether persons with particular strengths and vulnerabilities (maybe related to upbringing, losses, traumatic experiences and genes) develop so much anguish and psychache that suicide is conceived to be the only solution. For most of those suffering psychache, the major need is for someone to recognise the mental pain and to seek strategies to deal with it.

Examination of age patterns of male suicide, and of changes in those patterns over time [20, 21], can facilitate identification of factors that may be causative or protective in relation to suicide. Factors may interact. Some personality characteristics make it difficult to tolerate disability, loss, insults, pain or diminished self-regard. Recognition that male suicide rates peak in middle age, young adulthood or late life in one country but not in another may prompt hypotheses concerning which combination of sociocultural factors is more likely to be causative/protective. There is reason to believe that middle-age peaks seen in graphs of the male suicide rates of most of the 10 nations in 2015 were related to financial and other stresses that commonly trouble men at that age [50, 51]. There is good reason to ponder what events and situations have affected particular age groups, genders and populations. Recognition that rates have changed in a particular country can prompt examination of how and why period effects and cultural sensitivities could interact to result in such changes.

5. Conclusions

As shown in the above review of rates and age patterns of male suicide in 2015, there were substantial differences between nations. Age patterns of male suicide were bimodal in most English-speaking and Western European countries while East Asian patterns are commonly upward-sloping. Japan's has become more like the US trimodal pattern. Emergence of a peak in male suicide rates in middle age in various nations has been attributed to sociocultural factors related to financial and other crises. Although male suicide rates peaked at age 85+ years in 8 out of the 10 nations, studies have demonstrated considerable reductions in late life rates over recent years, Korea being the only one to report a strikingly increased rate. However, caution is needed when analysing suicide data, since there is evidence of worldwide undercounting related to misclassification of suicides as "undetermined deaths". There is marked variation between nations vary markedly in their rates of such deaths and how they are coded (using ICD-10). Whether diagnosed as a psychiatric disorder or not, it is likely that most of those dying by suicide experience unbearable anguish (psychache). Analysis of age patterns can help identify factors that may lead to mental turmoil and suicide.

Author contributions

JS is the sole contributor to this article.

Ethics approval and consent to participate

The data shown in this paper are public and available, and thus there is no need of ethical approvals and consent to participate in the study.

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Conflict of interest

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