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Annual Research Review: A meta-analytic review of worldwide suicide rates in adolescents

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Suicide is a leading cause of death among youth worldwide. The purpose of the current review was to examine recent cross-national trends in suicide mortality rates among 10- to 19-year-olds. This study extracted suicide mortality data from the World Health Organization's (WHO) Mortality Database for the most recent year (since 2010) from any country with available high-quality data (as defined by the WHO's guidelines). Data on access to lethal means (firearms, railways) and measures of economic quality (World Bank Income Group) and inequality (Gini coefficients) were obtained from publicly available data sources. Cross-national suicide mortality rates in youth were heterogeneous. The pooled estimate across all ages, sexes, and countries was 3.77/100,000 people. The highest suicide rates were found in Estonia, New Zealand, and Uzbekistan. Suicide rates were higher among older compared with younger adolescents and higher among males than females. The most common suicide methods were hanging/suffocation and jumping/lying in front of a moving object or jumping from a height. Firearm and railway access were related to suicide deaths by firearms and jumping/lying, respectively. Economic quality and inequality were not related to overall suicide mortality rates. However, economic inequality was correlated with a higher ratio of male:female suicides. This study provides a recent update of cross-national suicide trends in adolescents. Findings replicate prior patterns related to age, sex, geographic region, and common suicide methods. New to this review are findings relating suicide method accessibility to suicide mortality rates and the significant association between income inequality and the ratio of male:female suicide. Future research directions include expanding the worldwide coverage to more low- and middle-income countries, examining demographic groupings beyond binary sex and to race/ethnicity within countries, and clarifying factors that account for cross-national differences in suicide trends.
Keywords: Adolescence; epidemiology; prevalence; suicidal behavior; suicide.

Introduction

Suicide is a leading cause of death worldwide. Current estimates indicate that an individual will die by suicide somewhere in the world every 40 s (World Health Organization (WHO), 2014). This public health concern is perhaps even more alarming and puzzling when it comes to suicide death among youth – estimated to be the second leading cause of death among young people 10–24 years old (Centers for Disease Control and Prevention (CDC), 2017b; Patton et al., 2009; WHO, 2014). The purpose of the current review is to provide a recent estimate of worldwide suicide mortality rates in adolescents and to examine cross-national trends in these rates. Extending prior research, this study explores suicide mortality data in detail, including patterns in suicide methods, how access to lethal means relates to suicide rates, and how suicide rates vary cross-nationally based on indices of economic quality and inequality.

Although the specific causes of suicide among young people are complex and remain somewhat elusive (Bridge, Goldstein, & Brent, 2006; Cha et al., 2018; Hawton, Saunders, & O'Connor, 2012; Turecki & Brent, 2016), it is clear that suicide is a major public health concern among adolescents. Suicidal thoughts and behaviors are relatively rare during childhood but increase significantly during the transition to adolescence (Dervic, Brent, & Oquendo, 2008; Hepp, Stulz, Unger-Köppel, & Ajdacic-Gross, 2012; Nock, Borges, Bromet, Cha, et al., 2008; Nock et al., 2013). In addition to the increased prevalence during adolescence, there is also significant escalation from suicidal thoughts to suicidal behaviors during this developmental period. Most youth who transition from suicidal thoughts to suicidal behaviors will do so within 1–2 years after the onset of suicide ideation (Glenn et al., 2017; Nock et al., 2013). Moreover, available country-level estimates suggest that the suicide rate among adolescents has increased in recent years (OECD, 2017b). For example, in the United States of America (USA), the age-adjusted suicide rate increased by 24% from 1999 to 2014; the increase in rates for females was greatest among those aged 10–14 years, while males aged 10–14 years experienced the second largest percent increase among males during this time (Curtin, Warner, & Hedegaard, 2016). Among 15- to 19-

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year-olds, suicide rates increased for both sexes from 2007 to 2015; among females, the rate in 2015 was higher than any time in the prior 40 years (Curtin, Hedegaard, Minino, Warner, & Simon, 2017). Taken together, adolescence is a key developmental period for effective suicide intervention and prevention (Gould, Greenberg, Velting, & Shaffer, 2003; NAASP, 2014; WHO, 2014; Wyman, 2014).

A number of prior studies have estimated cross-national trends in suicide mortality rates among youth. Most of this previous research has used the World Health Organization's (WHO) Mortality Database (WHO, 2018b), which provides one of the best sources of information about worldwide mortality rates. Using this database, Wasserman, Cheng, and Jiang (2005) estimated a worldwide suicide rate for 15- to 19-year-olds of 7.4/100,000 people based on suicide mortality data collected in 1995 from 90 countries. The highest suicide rates in youth have been observed in New Zealand (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2016; McLoughlin, Gould, & Malone, 2015; Roh, Jung, & Hong, 2018), Finland (Bridge et al., 2006; Cha et al., 2018; McLoughlin et al., 2015; Roh et al., 2018), Ireland (Bridge et al., 2006; McLoughlin et al., 2015), Guyana (Kõlves & De Leo, 2016), Sri Lanka (Wasserman et al., 2005), and a range of former Soviet Union states (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2014, 2016; McLoughlin et al., 2015; Roh et al., 2018; Wasserman et al., 2005). In addition, suicide rates are found to be higher in older versus younger youth (Bridge et al., 2006; Cha et al., 2018; Roh et al., 2018). Finally, adolescent suicide deaths are much more common (2–4x higher) in males than females (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2014, 2016; McLoughlin et al., 2015; Roh et al., 2018; Värnik et al., 2009; Wasserman et al., 2005), consistent with sex differences in suicide rates observed among adults (Bachmann, 2018; Canetto & Sakinofksy, 1998; Chang, Yip, & Chen, 2019; Nock, Borges, Bromet, Cha, et al., 2008; Schrijvers, Bollen, & Sabbe, 2012; World Health Organization (WHO), 2016b). The major exceptions to this sex difference in youth have been observed in China (Bridge et al., 2006; McLoughlin et al., 2015; Wasserman et al., 2005), India (McLoughlin et al., 2015), Cuba (Wasserman et al., 2005), Ecuador (Wasserman et al., 2005), El Salvador (Wasserman et al., 2005), and Sri Lanka (Wasserman et al., 2005), all of which have reported higher suicide rates among females than males in at least one study.

The current review provides an updated estimate of worldwide suicide mortality rates among youth, aged 10–19 years, and examines cross-national trends in suicide rates. Like most prior studies examining worldwide suicide rates, this review uses the WHO Mortality Database. The present review builds on prior studies in three important ways. First, this review examines the time period from early to late adolescence (10- to 19-year-olds) and compares rates among younger (10- to 14-year-old) and older (15- to 19-year-old) adolescents. The current focus on this age range is critical, as most prior studies have examined either narrow age ranges (e.g., 15–19 years) that leave out key periods of adolescence, or wider age ranges extending into early adulthood (e.g., 5–29 years). Prior research reveals marked differences in the incidence of, and risk factors for, suicide-related outcomes across adolescent and adult developmental periods (Kõlves & De Leo, 2015; Lewinsohn, Rohde, Seeley, & Baldwin, 2001; Nkansah-Amankra, 2013), highlighting the need to more precisely examine the period of adolescence. Second, this review provides a more recent estimate of suicide rates by focusing on data since 2010. The majority of prior reviews have examined suicide rates over the past 15–20 years. Given the significant changes in suicide death rates over time (Curtin et al., 2016; OECD, 2017b), an updated review is needed. Third, this review considers a number of cross-national trends in suicide mortality rates. In addition to examining cross-national suicide rates as a function of age and sex, this review examines cross-national trends in specific suicide methods (Hepp et al., 2012; Kõlves & De Leo, 2017; Värnik et al., 2008, 2009), how rates vary based on access to lethal means (e.g., firearms and railways), and how rates vary as a function of economic quality and inequality (Bachmann, 2018; Shah, 2012).

Method

Search strategy for suicide mortality data

In line with prior studies (Bachmann, 2018; McLoughlin et al., 2015; Nock, Borges, Bromet, Cha, et al., 2008), we used two main strategies to obtain cross-national data on suicide deaths in 10- to 19-year-olds: (a) We accessed publicly available data sources of either cross-national or country-specific mortality data, and (b) we conducted a systematic review of empirical studies reporting national or cross-national suicide death data.[1] The resulting source for suicide mortality data was the WHO's Mortality Database (WHO, 2018b). The WHO Mortality Database (last updated May 2018) collects mortality and vitality statistics directly from nations' civil registration systems across the world and presents standardized mortality data by age, sex, year, and cause of death (coded according to the International Classification of Diseases, 10th revision [ICD-10; WHO, 2016a]). Available national data are categorized by data quality. Although the WHO recognizes 194 member states as of 2016, the completeness of data coverage varies by country, and several countries do not submit mortality statistics to the WHO. Developed countries more consistently report annual and complete data than developing nations, which often submit partial data covering subnational regions.

We restricted our use of the WHO database in three ways. First, we only included countries that had data available since 2010 in order to provide the best estimate of recent suicide rates. Data for the most recent year available for each country were included in this review. Second, since the present review focused on examining suicide death data in detail, we only included data for countries that were evaluated as 'high' quality (e.g., identifying ICD codes for the vast majority of suicide deaths), and excluded countries with 'medium' and 'low' quality data. Death registration data quality

classifications are based on three indices: (a) whether mortality data is submitted by ICD code, (b) whether mortality data has been submitted for multiple years, and (c) average usability of data submitted since 2007 (WHO, 2018a). Usability scores account for the proportion of reported deaths that are assigned to a poorly defined ICD death code. As of 2016, a nation's data are considered 'high' quality if that nation has supplied at least 5 years of data since 2007 that have achieved an average usability score of 80% or higher. A classification of 'medium' quality denotes that a nation's mortality data have an average usability score between 60% and 80%. 'Low' and 'very low' quality indicate usability scores below 60% and 40%, respectively.

Based on these criteria, 45 countries were included in this review[2] : Africa (n = 1), Asia (n = 6), Europe (n = 28), North America (n = 6), Oceania (n = 2), and South America (n = 2; see Table 2). For each country, we extracted suicide mortality data for 10-to to 19-year-olds using the WHO Cause of Death Query Online (CoDQL) tool. When available, we also extracted the following suicide mortality data: (a) age group: 10- to 14-year-olds and 15- to 19-year-olds, (b) sex: male and female, and (c) suicide method. WHO data provide method of suicide death based on the International Classification of Diseases, 10th revision (ICD-10; WHO, 2016a) codes X60-X84 indicating self-inflicted death[3] (see Data Analysis section).

Population data

Population estimates were extracted from the United Nations (UN) Population Division's World Population Prospects 2017 database (UNPD, 2017), which provides population data for all countries included in this review. The World Population Prospects database compiles national census data and data from specialized population surveys to provide population estimates by country, age, and sex (UNPD, 2017). Given that several countries do not report population estimates directly to the WHO, the WHO Mortality Database only provided total population data for approximately half of the countries included in this review. To calculate age-standardized death rates for nations that do not regularly report population data together with vital registration data, the WHO collaborates with the UN Population Division to collect global health statistics and population totals (WHO, 2018a). When possible, WHO population estimates and UN estimates were compared by year and age and were found to be nearly identical.

Access to lethal means

Data on access to lethal means were obtained from publicly available datasets. For train- and firearm-related suicide death, access to means was operationalized as density of means (i.e., railways and firearms), either per geographic area or persons.

Railway density data (km of lines per 1,000 km^2) per country were obtained from the International Union of Railways (International Union of Railways (UIC), 2016). Countries were categorized into one of seven density ranges (lowest density = 0–5 km of lines per 1,000 km^2; highest density ≥ 75 km of lines per 1,000 km^2). Although railway density information was not obtained for the same year as the mortality data, these estimates have increased only marginally (3.6%) over the past decade (UIC, 2016) and thus remained relatively stable during the period of data collection for this study.

Firearm accessibility was measured as the estimated number of civilian firearms per 100 persons, with data for each country obtained from the Small Arms Survey (Small Arms Survey, 2018). It is important to note that although the proportion of suicides deaths via firearm is sometimes used as a proxy for gun ownership (Alvazzi del Frate & Pavesi, 2014), the Small Arms Survey did not use suicide by firearm in calculating rates of civilian firearm ownership per country (Karp, 2018). Therefore, the firearm access and suicide death by firearm variables are independent, allowing their association to be examined. However, unlike railway estimates, firearm density has increased significantly over the past decade (estimated increase of 32% from 2006 to 2017 due to enhanced research methods and increased civilian holdings; Karp, 2018) and therefore was not a stable estimate over the data collection period for this study.

Urban population data (percentage of a country's total population living in urban areas in 2018) were obtained online from the United Nations Population Division (UNPD, 2018). These data were used as a proxy for access to tall structures, or heights, for jumping.

Economic quality and inequality

Included countries were classified by economic level according to the World Bank Income Groups (2019). These groupings are determined by the gross national income (GNI) per capita, reflecting the average income of a country's citizens. Groups are defined as high-income (>$12,506 in US Dollars), upper-middle-income ($3,896–$12,055), lower-middle-income ($996–$3,985), and low-income (<$995) (World Bank Group, 2019). Previous studies have used the World Bank Income Groups to examine how a country's economic quality relates to mental health outcomes (Ayuso-Mateos, Nuevo, Verdes, Naidoo, & Chatterji, 2010; Bromet et al., 2011; Nock, Borges, Bromet, Alonso, et al., 2008; Stein et al., 2010). The World Bank Income Group ratings were obtained for the same year as the most recent available WHO mortality data for each country.

Economic inequality was measured with the Gini index, or Gini coefficient, which measures income distribution in a country and is the most commonly used measure of economic inequality. The Gini index is assessed on a scale of 0 to 1, with 0 representing the least possible amount of inequality and 1 representing the greatest possible inequality in a country (Subramanian & Kawachi, 2004). Prior research has used Gini coefficients to compare how economic inequality relates to a range of psychiatric disorders (Burns, Tomita, & Kapadia, 2014; Cifuentes et al., 2008; Johnson, Wibbels, & Wilkinson, 2015; Yu, 2018). For the current study, Gini coefficients were obtained from the World Bank (2019) for the most recent available year. Although this may not align with the same year as the WHO mortality data for a given nation, Gini coefficients have been relatively stable over time (Li, Squire, & Zou, 1998).

Data analysis: estimates of suicide mortality

Pooled estimates. To estimate the pooled suicide mortality rates across all available countries (n = 45), we used the 'metafor' R package (Viechtbauer, 2010) to conduct a series of random-effects meta-analyses. Because suicide is a relatively rare event, there were several instances, especially pertaining to subgroups (e.g., females 10–14 years old), for which there were no suicide deaths. To account for the existence of these cases, we used the Freeman–Tukey transformation (Freeman & Tukey, 1950), which allows for proportions that equal 0. We calculated pooled estimates for suicide death by all methods, cross -tabulated by age group (10- to 19-year-olds, 10- to 14-year-olds, 15- to 19-year-olds) and sex (males and females combined, males only, females only). Each analysis produced an estimate of prevalence, which we standardized to prevalence per 100,000 people, as well as a 95% confidence interval for the estimate. The meta-analysis also produced two metrics of heterogeneity: the I^2 statistic, which quantifies the percent of variability across cases that is not due to chance, and a Q statistic, which, when significant, reflects a

high level of heterogeneity between cases (Higgins & Thompson, 2002).

Estimates by country. For country-level data, we calculated the mortality rate for each country, standardized to suicide deaths per 100,000 people. Given that we were interested in country-to-country differences, we did not use meta-analysis. In line with recommendations for reporting mortality rates (United States Department of Health, 2018) and consistent with prior reviews (Kõlves & De Leo, 2017), we excluded from analyses any cell with fewer than 10 events (i.e., suicide deaths).[4] Therefore, of the 45 countries with data available for suicide by any method, analyses included anywhere from 10 to 37 countries ($M = 21.78$ countries, $SD = 11.30$). When examining estimates by country and by method, there were ultimately fewer countries included due to the possibility that there were 0 suicides by any given method. We calculated statistics cross-tabulated by age group (10- to 19-year-olds, 10- to 14-year-olds, 15- to 19-year-olds) and sex (males and females combined, males only, females only). We also calculated the ratio of suicide mortality rates by males and females.

Suicide methods. We created higher-level groupings of suicide methods based on ICD-10 codes (WHO, 2016a), leading to a total of nine groups of methods: (a) self-poisoning, including drugs, medications, solvents, gases, and pesticides (codes X60-X69); (b) hanging/suffocation (code X70); (c) drowning (code X71); (d) firearms (codes X72-X74); (e) explosion, fire, steam, or hot objects (codes X75-X77); (f) sharp or blunt objects (codes X78-X79); (g) jumping from a height or jumping/lying in front of a moving object (codes X80-X81), which were combined because counts were too small for each code to be examined separately (referred to collectively as 'jumping/lying' from this point forward); (h) motor vehicle (code X82); and (i) other/unspecified methods (codes X83-X84). Using meta-regression, we calculated deaths per 100,000 people for males and females together, as well as males and females separately.

Data analysis: moderators of suicide mortality

Economic quality. To explore whether suicide rates differed by income group across all countries, we conducted a moderated meta-analysis (i.e., meta-regression with dummy variables) based on the recommendations provided by Viechtbauer (2010). As with the other meta-analyses performed, because meta-analysis is robust to very infrequent event counts, we included in the analysis any country with available data, even if they did not have more than 10 suicide deaths. Of the 45 countries with income group data, 34 were high, nine were upper-middle, and two were lower-middle. Given that we did not want to have two countries drive the moderated meta-analysis, we combined the lower- and upper-middle-income countries into one 'middle-income' group. We were also interested in whether the ratio of male:female suicides differed by income group. To explore this, we conducted a *t*-test using the male:female suicide death ratio as the outcome and income group as the predictor, in all adolescents (10- to 19-year-olds, among countries with >10 suicides) and 15- to 19-year-olds (also among countries with >10 suicides). We did not examine this relationship for the 10- to 14-year-old group because there were too few countries with more than 10 suicides ($n = 8$) to make a meaningful inference about the data.

Economic inequality. To explore whether suicide rates differed by economic inequality, we conducted a set of analyses similar to those for economic quality, but used the Gini coefficient instead of the economic quality group. Because the Gini coefficient, and therefore economic inequality, is a continuous variable, these analyses differed from those for economic quality in two ways: (a) The moderated meta-regression did not use dummy codes and (b) we conducted a correlation between Gini coefficients and male:female ratios instead of *t*-tests.

Access to lethal means. We examined how suicide methods varied as a function of lethal means access – specifically firearms (number of firearms per 100 people), railways (rail density per 1,000 km^2), and access to tall structures (% of individuals residing in urban areas). For each of the three moderators, we calculated a series of moderated meta-regressions for each method (i.e., separate models for each method) across all ages and sexes, rather than separately by age groups and sex in order to avoid potential type I errors as a result of multiple comparisons. In these cases, a significant *Q* statistic indicated the presence of a moderation effect.

Results

Suicide mortality

Pooled estimates. Table 1 displays the pooled suicide rates for adolescents by age group and sex. The pooled suicide rate across all sexes, 10- to 19-year-olds, was 3.77 per 100,000 (95% $CI = 3.15$–3.45, $I^2 = 96.87\%$, $Q = 1{,}587.92$, $p < .001$). There was considerable heterogeneity across analyses, reflecting the variability in cross-national suicide rates and

Table 1 Pooled estimates of suicide mortality rates per 100,000 people by age group (10- to 19-year-olds, 10- to 14-year-olds, 15- to 19-year-olds) and sex

Group	Estimate	95% CI lower	95% CI upper	I^2	Q	p
All 10- to 19-yo	3.77	3.15	4.45	96.87	1,587.92	<.001
All 10- to 14-yo	0.93	0.57	1.36	91.75	512.72	<.001
All 15- to 19-yo	6.04	5.01	7.15	96.02	1,173.68	<.001
Male 10- to 19-yo	4.91	4.06	5.83	94.63	1,034.97	<.001
Male 10- to 14-yo	0.76	0.32	1.33	87.79	349.65	<.001
Male 15- to 19-yo	8.41	6.96	9.99	93.01	793.55	<.001
Female 10- to 19-yo	1.99	1.45	2.61	93.92	673.83	<.001
Female 10- to 14-yo	0.64	0.25	1.15	79.65	209.88	<.001
Female 15- to 19-yo	2.98	2.06	4.03	92.95	511.46	<.001

yo, year-olds.

pointing to a need for caution in interpreting these findings.

Estimates by country. Table 2 displays the country-level descriptives by age group and sex. The rates for all ages (10- to 19-year-olds) inclusive of males and females ranged from 1.31/100,000 people (Israel) to 9.72/100,000 people (Estonia). The rates for 10- to 14-year-olds, both sexes (20/35 countries had <10 cases and were excluded), ranged from 0.28/100,000 people (United Kingdom) to 4.71/100,000 people (Kyrgyzstan). The rates for 15- to 19-year-olds, both sexes (0 countries had <10 cases), ranged from 2.30/100,000 people (Israel) to 17.6/100,000 people (New Zealand).

Pertaining to the ratio of males to females who died by suicide, males were more likely than females to die by suicide in all countries except Uzbekistan (where the male:female ratio was 0.95). In all other countries across both age groups, the male:female suicide ratio ranged from 1.14 (Sweden) to 2.73 (Italy). A similar pattern was found across most countries when examining 15- to 19-year-olds only; the male:female ratio ranged from 1.21 (South Korea) to 3.13 (Italy), with the exception of Uzbekistan (ratio: 0.87). We do not report ratios for 10- to 14-year-olds because data were only available for both sexes for 7 out of 35 countries. However, for almost all countries where data were available for both sexes of 10- to 14-year-olds, rates were higher among males than females (with the exception of Canada).

Suicide methods. Figure 1 presents stacked bar charts showing the distribution of suicide methods across countries, for both males and females combined and separately. Several findings were consistent across countries. Hanging/suffocation was the

Table 2 Cross-national suicide mortality rates per 100,000 people by country, age group (10- to 19-year-olds, 10- to 14-year-olds, 15- to 19-year-olds), and sex

	All			Male only			Female only			Male:Female ratio	
Country	10–19	10–14	15–19	10–19	10–14	15–19	10–19	10–14	15–19	10–19	15–19
Australia	5.49	0.99	9.83	6.39	–	11.75	4.54	–	7.79	1.41	1.51
Austria	3.64	–	6.33	4.17	–	7.53	3.06	–	5.01	1.36	1.50
Belgium	2.78	–	4.90	3.86	–	7.11	1.64	–	–	2.36	–
Brazil	2.07	0.59	3.56	2.83	0.62	5.08	1.29	0.56	2.02	2.20	2.52
Canada	5.01	1.87	7.71	5.62	1.56	9.10	4.37	2.20	6.23	1.29	1.46
Chile	5.06	1.74	8.08	6.73	–	11.68	3.31	2.20	4.33	2.03	2.70
Costa Rica	3.45	–	5.00	4.59	–	7.08	–	–	–	–	–
Croatia	3.47	–	6.50	5.86	–	10.99	–	–	–	–	–
Cuba	2.41	–	4.10	3.54	–	5.75	–	–	–	–	–
Czech Republic	3.90	–	8.07	5.34	–	11.05	2.38	–	4.93	2.24	2.24
Estonia	9.72	–	16.70	17.34	–	32.45	–	–	–	–	–
Finland	4.96	–	8.93	6.80	–	12.51	–	–	–	–	–
France	2.04	0.66	3.45	2.63	0.69	4.61	1.42	0.62	2.23	1.86	2.06
Germany	2.75	0.51	4.75	3.44	–	6.21	2.01	0.72	3.17	1.71	1.96
Hungary	2.54	–	4.81	3.76	–	7.01	–	–	–	–	–
Ireland	3.94	–	7.65	5.35	–	9.91	–	–	–	–	–
Israel	1.31	–	2.30	1.85	–	3.29	–	–	–	–	–
Italy	1.50	0.42	2.58	2.16	–	3.84	0.79	–	1.23	2.73	3.13
Japan	4.61	1.58	7.47	6.23	2.11	10.12	2.91	1.02	4.69	2.14	2.16
Kyrgyzstan	7.38	4.71	10.00	8.77	6.55	10.95	5.94	–	9.02	1.48	1.21
Lithuania	6.25	–	8.88	10.14	–	13.57	–	–	–	–	–
Mexico	4.81	2.07	7.57	6.24	2.39	10.15	3.34	1.73	4.94	1.87	2.05
Moldova	6.45	–	8.87	9.54	–	13.46	–	–	–	–	–
Netherlands	2.39	–	3.83	2.91	–	4.60	1.83	–	3.02	1.59	1.52
New Zealand	9.36	–	17.60	9.93	–	19.36	–	–	15.76	–	1.23
Norway	3.00	–	4.59	4.00	–	6.54	–	–	–	–	–
Romania	2.77	1.52	3.98	3.93	–	6.32	1.55	–	–	2.54	–
Slovakia	2.14	–	4.04	3.47	–	6.57	–	–	–	–	–
South Korea	4.29	1.25	6.64	4.66	1.31	7.24	3.88	1.17	5.98	1.20	1.21
Spain	1.47	–	2.67	1.99	–	3.49	0.92	–	1.80	2.17	1.94
Sweden	3.99	–	6.45	4.23	–	7.32	3.73	–	5.51	1.14	1.33
Switzerland	4.02	–	7.04	5.31	–	9.30	2.67	–	4.66	1.98	2.00
United Kingdom	2.35	0.28	4.27	3.31	–	6.18	1.34	–	2.26	2.48	2.73
United States of America	5.91	1.98	9.75	8.39	2.39	14.23	3.33	1.56	5.06	2.52	2.81
Uzbekistan	7.98	3.98	11.46	7.78	4.41	10.71	8.20	3.52	12.25	0.95	0.87

Excluded countries with suicide death counts (for all methods) <10 were as follows: Brunei Darussalam, Denmark, Iceland, Latvia, Luxembourg, Macedonia, Malta, Mauritius, Saint Vincent and the Grenadines, and Slovenia. Missing cells reflect <10 suicide deaths in that individual cell.

most common method of suicide across all countries and for both sexes. With few exceptions (e.g., Estonia, New Zealand, Uzbekistan, Kyrgyzstan, Mexico, and Ireland), jumping/lying was the second most common method of suicide across both sexes. When examining sex differences in suicide methods across all countries with >10 cases, a significant difference was found only for self-poisoning ($Q = 21.25$, $p < .001$) such that males were more likely to self-poison than females. The average self-poisoning mortality rate per 100,000 people was 0.42/100,000 for males and 0.21/100,000 for females. (Of note, this study was underpowered to examine self-poisoning by specific substance, such as drugs vs. other substances.) For all other methods, sex differences were nonsignificant ($Q = <.0001–2.15$ $p = .142–.995$).

Moderators of suicide mortality rates

Economic quality. Results of the moderated meta-analysis showed that pooled estimates did not differ by World Bank Income Group across any of the demographic groups (i.e., overall and by age or sex; $Q = 0.02–3.25$, $p = .071–.895$). There was no difference in the male:female ratio for the 10- to 19-year-olds ($t = 0.29$, $p = .786$) or the 15- to 19-year-olds ($t = 0.75$, $p = .495$).

Economic inequality. Results of the moderated meta-analysis showed that pooled estimates did not differ by Gini coefficient across any of the demographic groups (i.e., overall and by age or sex; $Q = 0.14–1.03$, $p = .310–.710$). There was also no correlation between the male:female suicide ratio for 10- to 19-year-olds and Gini coefficient ($r = .29$, $p = .226$). However, there was a significant correlation between the male:female suicide ratio for 15- to 19-year-olds and Gini coefficient such that in countries with more inequality (higher Gini), there was a larger ratio of male:female suicides ($r = .55$, $p = .023$).

Associations between access to lethal means and suicide mortality rates

Access to firearms. When examining number of firearms per 100 people as a moderator of suicide mortality rates, we found that greater firearm access moderated the rate of suicide due to firearms ($Q = 32.40$, $p < .001$) but was unrelated to all other methods of suicide ($p = .272–.979$).

Access to railways. When examining access to railways as a predictor of suicide mortality rates, we found significant omnibus tests for hanging/suffocation ($Q = 16.88$, $p = .009$) and jumping/lying ($Q = 16.51$, $p = .011$). Omnibus tests for other suicide methods were nonsignificant ($Q = 1.98–6.95$, $p = .326–.921$). When examining pairwise post hoc comparisons for hanging/suffocation, there were, in general, differences between the lowest and highest densities, with higher rates of suicide due to hanging/suffocation in the areas with lower railway density. Specifically, rail density of 0–5 km per 1,000 km^2 of lines differed significantly from all higher densities (all $p < .001$), ≥100 km per 1,000 km^2 of lines differed significantly from all lower densities ($p = <.001–.002$), and 5–10 km per 1,000 km^2 and 50–75 km per 1,000 km^2 differed significantly ($p = .037$). When examining pairwise post hoc comparisons for jumping/lying, there were significant differences among all pairs ($Q = 6.91–122.67$, all $p < .001$), where areas of lower rail density had lower rates of suicide due to jumping/lying than areas of higher rail density.

Urban population. When examining whether percent of the population in an urban area moderated the suicide mortality rate, we found no moderation for any of the suicide methods ($Q = 0.003–2.72$, $p = .099–.951$).

Discussion

Our findings replicate and extend prior research in six important ways. First, our review provides an estimated suicide rate for the 10- to 19-year-old period (using WHO Mortality Data from 2010 to 2016) of 3.77/100,000 people. There are two important considerations when interpreting this rate: (a) Considerable heterogeneity was found in suicide mortality rates cross-nationally (which we discuss in the next section), and (b) our analyses included all available high-quality WHO mortality data, but only represent a subset of primarily Western countries worldwide (an issue we discuss in the Limitations section). However, this overall suicide rate among 10- to 19-year-olds is consistent with a prior study (Roh et al., 2018) that found a suicide rate of 3.94/100,000 people among 10- to 19-year-olds from 29 Organisation for Economic Co-operation and Development (OECD) countries during the period from 1995 to 2012. In addition, our 15- to 19-year-old rate of 6.04/100,000 people is similar, although lower, than the rate of 7.4/100,000 people found by Wasserman et al. (2005) among older (15–19 years old) adolescents from 90 WHO countries in 1995. Therefore, although these studies included data from different countries over different time periods, rates were relatively consistent for this population.

Second, at the country level, this review replicates higher suicide rates for adolescents from New Zealand, as well as Estonia and Uzbekistan (both former Soviet Union States) (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2016; McLoughlin et al., 2015; Roh et al., 2018; Wasserman et al., 2005). Given that high rates in these regions have been documented for decades, a variety of explanations have been provided, although many have not

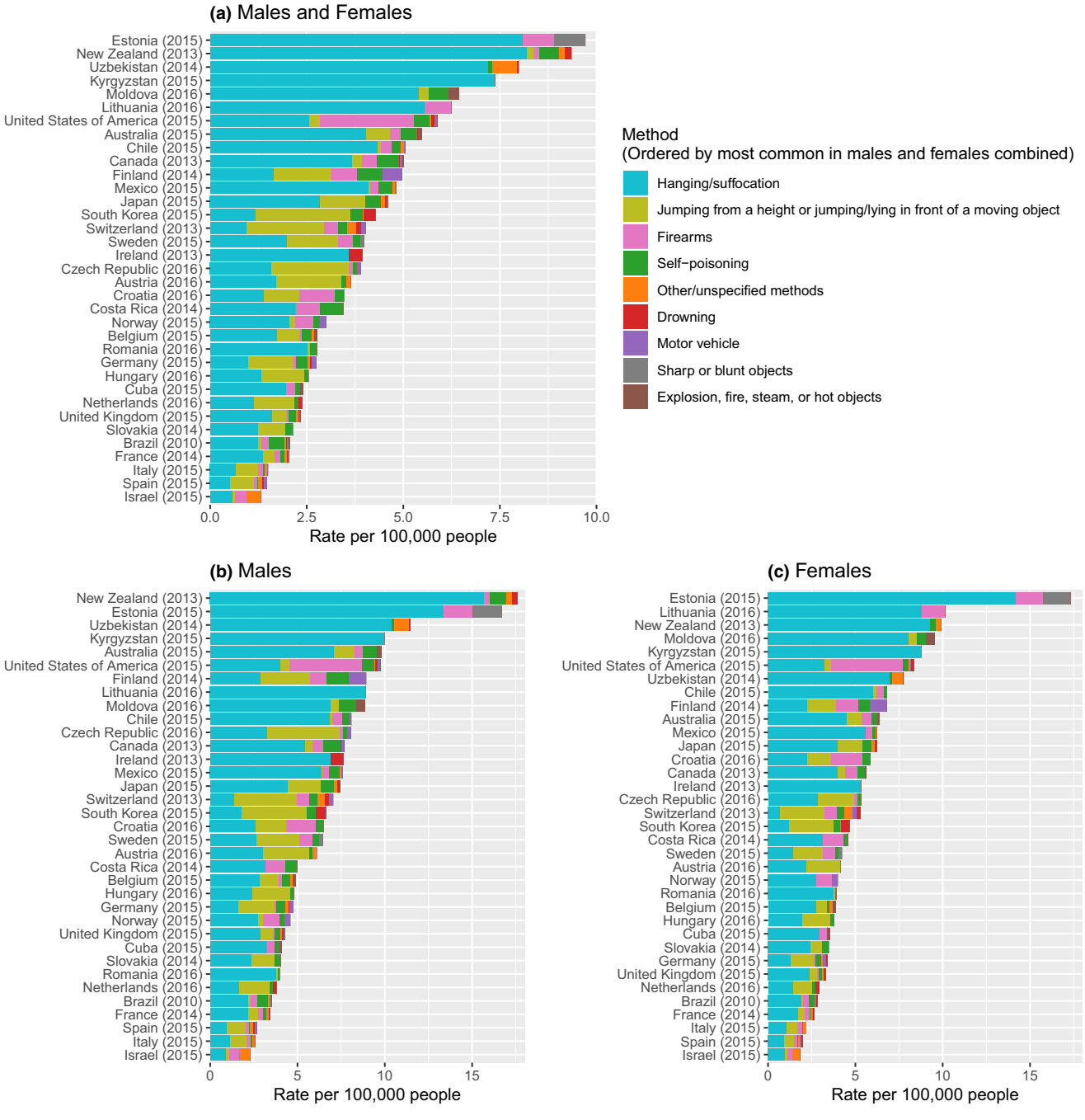

Figure 1 Cross-national suicide mortality rates by suicide method in 10- to 19-year-olds among (A) all youth, males and females, (B) males only, and (C) females only

been examined empirically or compared cross-nationally.

High rates of suicide mortality among youth in New Zealand have been recognized as a major public health concern for decades (Associate Minister of Health, 2006). Disproportionately high suicide death rates have been found among youth from indigenous Māori populations, especially young Māori males. This disparity may be partially explained by the socially and economically disadvantaged status of Māori populations in New Zealand, evidenced by the disproportionate number of Māori youth receiving welfare services (Beautrais & Fergusson, 2006). Additionally, the elevated suicide rate among Māori youth may reflect the unique effects of colonization experienced by indigenous youth, including cultural alienation and identity confusion (Beautrais & Fergusson, 2006). Moreover, New Zealand consistently reports high rates of child abuse and neglect and bullying in school. A longitudinal study of 55,000 New Zealand children (under the age of 18) found that 23.5% had a report about their welfare made to Child Protective Services (CPS) by the age of 17 (Rouland & Vaithianathan, 2018). Adolescents involved with CPS and other social welfare systems were found to be at elevated risk of suicide death

(Beautrais, 2001). In a 2015 cross-national study of OECD countries, New Zealand reported the second highest adolescent bullying rate of the 51 countries examined, with over 25% of adolescents experiencing some form of bullying multiple times a month, and 18.1% of adolescents met the criteria for 'frequent bullying' – more than twice the rate of the 50 other countries surveyed (OECD, 2017a). Government initiatives in New Zealand have aimed to address this elevated suicide risk and improve mental health care (Associate Minister of Health, 2006). However, prevention efforts, including means restrictions, are challenging, as most suicide deaths occur by hanging in private dwellings (Taylor, 2010). Of note, hanging is used more commonly among Māori than nonindigenous populations (Taylor, 2010). A recent review indicated that, although research is growing, few intervention and prevention programs in New Zealand have been evaluated (Coppersmith, Nada-Raja, & Beautrais, 2018).

Elevated suicide rates were also reported among youth in Estonia and Uzbekistan, consistent with prior studies finding higher rates among youth living in former Soviet Union states (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2014, 2016; McLoughlin et al., 2015; Roh et al., 2018; Wasserman et al., 2005). However, unlike New Zealand, little research has explored specific risk factors that contribute to high rates in these regions. Under the Soviet Union, suicide was a classified subject and suicide statistics were kept secret or discarded, delaying and discouraging the emergence of suicide as an acknowledged public health concern in this region (Wasserman & Värnik, 1998). The collapse of the Soviet Union in 1991 led to numerous social, political, and economic difficulties as former Soviet states rebuilt as independent nations. Estonia, in particular, experienced a sharp increase in suicide deaths among its Russian immigrant minority following independence from the Soviet Union as Russian immigrants lost their previously privileged status (Värnik, Kõlves, & Wasserman, 2005). Suicide rates in this region may also be related to the transition from a strict Soviet campaign against alcohol to more lax policies regulating alcohol (Kõlves & De Leo, 2016). Increased accessibility of alcohol led to a higher incidence of alcohol-related suicide deaths among adults (Kõlves, Milner, & Värnik, 2013; Värnik, Kõlves, Väli, Tooding, & Wasserman, 2007), and studies conducted in some former Soviet countries found that changes in national alcohol consumption were linked with fluctuations in mortality rates (Kõlves & De Leo, 2016; Kõlves et al., 2013). More research is needed, however, to clarify how alcohol consumption among adolescents in these countries may contribute to higher rates of suicide among youth.

A third finding from this review replicates a well-established trend that suicide rates are higher among older adolescents (Kõlves & De Leo, 2017; Roh et al., 2018) and young adults (Bridge et al., 2006; Cha et al., 2018) compared with younger adolescents. The age finding is also consistent with research describing the trajectories of suicidal thoughts and behaviors during adolescence, specifically that the onset of suicide ideation typically occurs during early adolescence (around ages 11–13) and, for a subgroup of youth, transitions to suicidal behavior during later adolescence (around age 15 or 16; Glenn et al., 2017; Nock et al., 2013). This previous research may suggest the existence of a developmental process (or set of processes) by which adolescents become more capable of engaging in suicidal behavior as they transition from early to later adolescence. Although the nature of these developmental processes remains unclear, there are several key differences between younger and older adolescents that may be relevant to changes in suicide risk (Dervic et al., 2008). First, the rise in suicidal thoughts and behaviors across adolescence coincides with increases in rates of other forms of psychopathology that confer risk for suicide, such as nonsuicidal self-injury, depression, substance use disorders, and certain anxiety disorders (Costello, Copeland, & Angold, 2011; Glenn et al., 2017; Nock et al., 2009). Second, compared to younger adolescents, older adolescents engage in more risk-taking behaviors (Braams, van Duijvenvoorde, Peper, & Crone, 2015), another known risk factor for suicidal thoughts and behaviors (Ammerman, Steinberg, & McCloskey, 2018). Third, older adolescents have more fully developed cognitive facilities than younger adolescents, which may intensify the complexity and severity of maladaptive thinking. For instance, increases in metacognition and abstract reasoning may enhance the ability to ruminate (Papageorgiou & Wells, 2003), and increases in future thinking abilities may facilitate hopelessness (Kosnes, Whelan, O'Donavan, & McHugh, 2013). Thus, types of negative cognition commonly associated with suicidal thoughts and behaviors (Cha, Wilson, Tezanos, DiVasto, & Tolchin, 2019) may become more advanced during older adolescence. Moreover, normative developmental changes in adolescent social networks that make peers more influential may also contribute to increased potential for imitation of risky behaviors, including modeling of suicidal behavior (Pickering et al., 2018). Finally, individuals with histories of multiple suicide attempts are at especially high risk of later suicide death (Kochanski et al., 2018). Beginning at age 17, most suicide attempts are repeat attempts (Goldston et al., 2015); thus, older adolescents may be at increased risk of suicide death due to increased experience engaging in suicidal behavior. Taken together, these observations suggest that higher rates of suicide during older adolescence may be due, at least in part, to other developmental changes during this period.

Fourth, higher suicide rates were reported among males (4.83/100,000 individuals) compared with females (1.95/100,000 individuals) in this age range. This sex effect is consistent with many prior studies in youth (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2014, 2016; McLoughlin et al., 2015; Miranda-Mendizabal et al., 2019; Roh et al., 2018; Värnik et al., 2009; Wasserman et al., 2005) and is also found among adults (Bachmann, 2018; Canetto & Sakinofksy, 1998; Chang et al., 2019; Nock, Borges, Bromet, Cha, et al., 2008; Schrijvers et al., 2012). Higher suicide death rates among males have been attributed to a range of factors, including greater use of lethal means (e.g., hanging and use of firearms; Callanan & Davis, 2012) and higher incidence of risk factors related to suicide death, such as substance use and aggressive and risk-taking behaviors (Bozzay, Liu, & Kleiman, 2014). Although the sex effect (with higher rates among males) was observed in most countries, the main exception to this trend was Uzbekistan (ratio male:female 0.95), where suicide rates between sexes were relatively comparable. In addition, 10 other countries (across North America, Europe, and Asia) had a male:female ratio of <2, which is surprising given prior findings that the suicide rate among males is at least 2–4 times higher than among females (Bridge et al., 2006; Cha et al., 2018; Kõlves & De Leo, 2016; McLoughlin et al., 2015; Roh et al., 2018; Värnik et al., 2009; Wasserman et al., 2005). Taken together with prior studies, these findings suggest that although overall suicide rates are higher among males than females, this sex difference is not uniform cross-nationally nor stable over time. Variation in suicide deaths by sex underscores an important role for cultural factors in suicidal behavior among youth.

Fifth, this review extends prior work by examining cross-national differences in suicide methods among adolescents. Hanging/suffocation was the most common method of suicide death worldwide among 10- to 19-year-olds, followed by jumping/lying in front of a moving object or jumping from a height, consistent with prior studies in youth (Hepp et al., 2012; Kõlves & De Leo, 2017; Värnik et al., 2008, 2009). Although hanging/suffocation is also a common method of suicide death among adults, previous research has found that jumping from a height and railway suicide deaths are much more common in youth than adults, and intoxication is less common among youth than adults (Hepp et al., 2012).

Although certain methods were more common overall, there were also differences between sexes. Males were more likely to die by self-poisoning than females, contrary to prior findings of higher rates of self-poisoning in females compared with males (Hepp et al., 2012; Kõlves & De Leo, 2017). However, a number of studies have found that self-poisoning by drugs is higher for females, while self-poisoning by other substances is higher for males (Rajapakse, Griffiths, Christensen, & Cotton, 2014; Värnik et al., 2008, 2009). Although the current study was unable to examine differences in self-poisoning by specific source, this remains an important direction for future research. Interestingly, there were no sex differences in suicide by firearm, as has been found in previous research (Hepp et al., 2012; Kõlves & De Leo, 2017; Värnik et al., 2009). However, given that suicide death counts were low, the nonsignificant findings should be interpreted with caution.

Notably, we found that use of particular suicide methods varied based on cross-national differences in access to these methods. Specifically, increased access to firearms within a country was strongly related to suicide death by firearm in that country, but not to suicide death by other methods. However, as discussed in the Methods section, firearm access was not stable over the period of data collection for this study – a notable limitation and opportunity for future research. Nevertheless, these findings highlight the importance of means restriction of firearms in countries with greater firearm access. Improved firearm legislation in New Zealand (Beautrais, Fergusson, & Horwood, 2006) and firearm storage in the United States (Brent et al., 1991; Grossman et al., 2005) have been related to reduced suicide rates. In addition, greater access to railways was associated with jumping/lying in front of a moving object (e.g., train) or jumping from a height. Some successful prevention strategies for railway deaths include use of sliding doors to limit access to rail track and creating deep channels between rails (Krysinska & De Leo, 2008; Pirkis et al., 2015). Moreover, a recent meta-analysis of prevention strategies for 'suicide hotspots' (where most deaths were due to jumping from a height) found evidence for reduced suicide rates with means restriction by building fences or rails to limit access (Pirkis et al., 2015).

Although we were able to measure access to certain suicide methods (i.e., firearms and railways), we were unable to estimate access to methods used for hanging/suffocation – the most commonly reported method among youth. Just as it is difficult to measure access, it is also difficult to *restrict* access to means used for hanging/suffocation – an issue that has made suicide prevention by hanging/suffocation in youth extremely challenging (Sarchiapone, Mandelli, Iosue, Andrisano, & Roy, 2011). This is particularly alarming in light of recent findings from the United States, indicating that suicide deaths by hanging/suffocation are on the rise among youth (Bridge et al., 2015; Sullivan, Annest, Simon, Feijun, & Dahlberg, 2015).

Sixth, the current review found that suicide rates overall were not significantly associated with the included indices of economic quality and inequality. Although ours is not the only study to find that

economic indices did not significantly relate to suicide rates (Bremberg, 2017; Vijayakumar, Nagaraj, Pirkis, & Whiteford, 2005), this finding is somewhat surprising in light of converging evidence, suggesting that economic factors have a significant impact on suicidal behavior (Bachmann, 2018). For instance, economic crises, and high unemployment rates in particular (Nordt, Warnke, Seifritz, & Kawohl, 2015), have been broadly linked to suicide deaths (WHO, 2014). In addition, lower socioeconomic indices are associated with suicide attempts across the world (Andres, Collings, & Qin, 2009; Burrows & Laflamme, 2010; Fang, 2018; Ki, Sohn, An, & Lim, 2017). However, less research has examined how economic indices relate to suicide deaths cross-nationally. It is important to note that in the current study, the majority of included countries (93%) were from high- or upper-middle-income groups. Therefore, the null findings may be due to restricted worldwide coverage – an issue we discuss in the Limitations section. Moreover, the included measure of national economic inequality may fail to capture important heterogeneity of inequality between cities within a country (Glaeser, Resseger, & Tobio, 2009).

Although economic indices were not related to suicide rates in the overall sample, there was a moderate to strong correlation between economic inequality (Gini coefficient) and the male:female suicide death rate ratio among 15- to 19-year-olds; that is, greater income inequality was associated with a higher suicide rate for males compared with females within a country. This finding is consistent with some research, suggesting that economic hardships may be related to poorer mental health outcomes among males compared with females. For instance, in a large cross-national study, Gini coefficients were significantly related to depressive symptoms in males but not females (Yu, 2018). In addition, in the United States, lower-income school contexts have been related to increased suicide ideation and attempts among males but not females (Fang, 2018). Moreover, a study in Denmark found that lower income and unemployment were related to suicide deaths for all adults, but effects were greater among males (Andres et al., 2009). Greater risk among males in poorer economic circumstances may be related to their role as primary income earners for their families in many countries (Mann & Metts, 2017). However, further research is needed to understand the mechanism of risk, particularly among youth, and to suggest potential targets for prevention.

Limitations and future directions

Although this review significantly extends knowledge of cross-national suicide trends in youth, limitations of this research warrant discussion. First, this review was limited in its worldwide coverage of only 45 (mostly high- and middle-income) countries out of the 194 WHO member countries. There are surprisingly little cross-national data on suicide mortality rates that are publicly available beyond the WHO Mortality Database. Of the countries included in the WHO database, data that are determined to be of 'high' quality are predominantly from countries in Europe, North America, Asia, and two high-income countries in Oceania (New Zealand and Australia); coverage of South America and Africa is limited. As a result, the current findings may not accurately estimate suicide rates in youth worldwide, particularly among these underrepresented regions.

The dearth of good-quality suicide mortality data worldwide may be due to significant underreporting (e.g., stigma) and misclassification of suicidal behaviors (e.g., lack of knowledgeable medical professionals), particularly in countries where suicidal behavior is illegal (Bachmann, 2018; De Leo, 2015; WHO, 2014). Additionally, many countries – including India, China, and the majority of nations in Africa – have not yet developed national death registration systems. As of 2010, <30% of the global population resided in countries with established death registration systems, resulting in lower quality mortality data for these regions (Bhalla, Harrison, Shahraz, & Fingerhut, 2010). The WHO estimates that suicides in countries without good-quality data account for approximately 71% of global suicide deaths annually. Good vitality registration data are disproportionately available for wealthier countries, with high-quality coverage for 95% of suicides in high-income countries but only 8% of all estimated suicide deaths in low- or middle-income countries (WHO, 2014). Greater cross-national coverage is greatly needed to more accurately estimate worldwide suicide mortality rates. Notably, in 2014, the World Bank and the WHO published a global investment plan to increase the number and quality of national civil registration and vital statistics systems (CRVS) in low- and middle-income countries (World Bank & World Health Organization (WHO), 2014). The initiative aims to both strengthen existing national CRVS systems and to catalyze the implementation of new systems by developing model CRVS legislation and expanding training for physicians and other medical staff responsible for registering vital statistics (World Bank & World Health Organization (WHO), 2014)).

Second, due to low counts, we were limited in our ability to examine all suicide methods. For instance, we had to combine jumping from a height and jumping/lying in front of a moving object. Although both are violent methods, prevention efforts, such as restricting access to means, may be distinct. In addition, we were unable to examine differences in the specific substances used for self-

poisoning. As already noted, there may be important sex differences in overdosing via drugs (higher in females) versus other substances (higher in males) (Rajapakse et al., 2014; Värnik et al., 2008, 2009).

Third, we examined cross-national trends based on binary female and male sex rather than gender or gender identity. At present, there is a substantial dearth of information regarding suicide death rates among nonbinary, transgender, and gender-expansive youth. Only recently have large-scale, nationally representative studies, such as the USA's Youth Risk Behavior Surveillance System (CDC, 2019) and the National Violent Death Reporting System (NVDRS; CDC, 2016), begun to consider including gender-expansive demographic characteristics in their measures (CDC, 2017a). Recent reporting data suggest important sex-based differences in suicide rates and forms of suicidal behavior. For example, a report of data from the NVDRS between 2013 and 2015 examining suicide decedents, 12- to 29-year-olds, in 18 states within the United States (Ream, 2019), found that 13% of transgender males and 8% of transgender females´ suicide deaths were due to firearms as compared to 55% and 34% of cisgender, heterosexual males and females, respectively (Ream, 2019). However, these data were limited in two key ways: They were not nationally representative, and transgender identity was coded based on information included in reports from law enforcement and medical examiners (Ream, 2019). The latter is a significant limitation given that gender identity is often not listed on death certificates or coroners' reports (Haas & Lane, 2015; Haas et al., 2010; Ream, 2019). However, data from individual studies conducted in the United States suggest rates of suicide ideation (i.e., thoughts of killing oneself) and suicide attempts (i.e., self-directed injury with at least some intent to die) may be as high as 31% and 17%, respectively, among transgender youth, compared with 11% and 6% in matched cisgender peers (Reisner et al., 2015). There is little information available for transgender youth in Asian, African, and South American countries (Adams, Hitomi, & Moody, 2017; McNeil, Ellis, & Eccles, 2017). Future cross-national research would benefit from incorporating comprehensive demographic questions surrounding gender and gender identity to estimate the suicide death rate among nonbinary, transgender, and gender-expansive youth.

Fourth, although this review examined several important cross-national trends, many potential moderators of interest could not be examined (see Cha et al., 2018; for a review of other important sociodemographic factors). For instance, we were not able to examine racial and ethnic differences within countries given the limited demographic information provided in the WHO Mortality Database. Examining suicide rates only at the aggregated country level may mask important differences based on race and ethnicity within countries. Illustrative of major differences are high suicide rates among indigenous, or native, youth in countries such as New Zealand (Beautrais & Fergusson, 2006), Australia (Cantor & Neulinger, 2000), Brazil (Coloma, Hoffman, & Crosby, 2006), and the United States (Leavitt et al., 2018). Moreover, high suicide rates have been reported among racial minority youth (e.g., Black children, 5–11 years old, in the United States, Bridge et al., 2015). Differences in youth suicide risk also have been reported as a function of immigrant generation status (Peña et al., 2008). These examples highlight the importance of examining cross-national and intranational trends based on racial, ethnic, and generational status factors in future research.

Finally, this review provides primarily descriptive and correlational information about worldwide suicide rates in adolescents. Although useful for understanding current cross-national trends, inferences should not be made about causation. Future research is needed to understand how factors such as access to lethal means and economic inequality may directly influence suicide rates.

In summary, the current review provides an updated estimate of worldwide suicide rates in adolescents, 10–19 years old, using the WHO Mortality Database from 2010 to 2016. Replicating prior research, suicide deaths were overall more common among male and older (15–19 years old) adolescents, hanging/suffocation was the most common method, and highest rates were found in Estonia, New Zealand, and Uzbekistan. This review contributes new information through findings that access to firearms and railways were related to suicide deaths by firearms and jumping/lying in front of a moving object or jumping from a height, respectively. Similar to prior reviews, this study was limited in its worldwide coverage of suicide rates and trends. Important future research directions include expanding the worldwide coverage to more low- and middle-income countries, examining suicide trends among nonbinary gender groups and by race/ethnicity within countries, and clarifying factors that account for cross-national differences in suicide rates.

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Key points

- Suicide is a leading cause of death among 10- to 19-year-olds worldwide.
- Suicide mortality rates, based on the World Health Organization's Mortality Database 2010–2016, varied worldwide. The highest suicide rates were found among youth in Estonia, New Zealand, and Uzbekistan.
- Suicide rates were higher among older (15–19 years old) compared with younger (10–14 years old) adolescents worldwide, and overall higher among males compared with females.
- The most common suicide methods were hanging/suffocation and jumping/lying in front of a moving object or jumping from a height.
- Firearms access and railway access were related to firearm suicide deaths and jumping/lying in front of a moving object or jumping from a height, respectively.

Notes

1. Two main strategies were used to obtain cross-national data on suicide deaths in 10- to 19-year-olds. First, we searched for publicly available data sources of either cross-national or country-specific mortality data. Ultimately, we found that other data sources were either limited in accessibility, were not nationally representative, or the source of the data overlapped with the larger WHO database (in these cases, the WHO was prioritized over other data sources because it provided the most consistent cross-national information). The second intended data source was a systematic review of empirical studies with data collection between 2010 and 2018 reporting national or cross-national suicide death data. Two major scientific databases (PubMed and PsycINFO) were searched for terms relating to suicide, epidemiology/prevalence, and youth/adolescence. However, no articles from this search met the inclusion criteria for our review. The key reasons for exclusion were as follows: The data were outside the time frame for our review (i.e., data collected prior to 2010), the sample was outside our age range (i.e., >19 years), the data were not nationally representative, or the data overlapped with the WHO database. Therefore, although the search was conducted across multiple sources, the WHO Mortality Database ultimately served as the publicly available data source to inform the current study. (Additional information about the search strategy is available upon request.)
2. Puerto Rico met the main inclusion criteria for the review but did not have enough mortality data available and therefore was excluded from all analyses.
3. The following additional ICD-10 codes were considered but not included in the current study. *U03 (suicide as an act of terrorism) is not available in the WHO Mortality Database and therefore not included in the current study. Y87.0 (late effects of intentional self-harm) was not included in the current study for three reasons: (a) Data using this code were missing for approximately half of the countries included in this meta-analysis, (b) this code has not been included in most prior cross-national suicide mortality studies in youth, and (c) does not specify suicide method, which was a major focus of the current study.
4. The most commonly excluded countries with suicide death counts <10 were as follows: Brunei Darussalam, Denmark, Iceland, Latvia, Luxembourg, Macedonia, Malta, Mauritius, Saint Vincent and the Grenadines, and Slovenia.

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