Suicide among agricultural, forestry, and fishery workers: a systematic literature review and meta-analysis

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Review

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Our findings confirmed the excess of suicide risk among agricultural, forestry, and fishery workers and quantified this excess by a pooled effect size of 1.48 (95% CI 1.30-1.68). This excess may be even higher for such workers in Japan. This review highlights the need for suicide prevention policies focusing on this specific population of workers.

Affiliation: INSERM U1085, IRSET, Equipe ESTER, Rue Haute de Reculée, F-49045 ANGERS Cedex 01, France. isabelle.niedhammer@inserm.fr

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Suicide among agricultural, forestry, and fishery workers: a systematic literature review and meta-analysis

by Justine Klingelschmidt, MPH,[1, 2, 3] Allison Milner, PhD,[4] Imane Khireddine-Medouni, MPH, MD,[3] Katrina Witt, DPhil,[5] Evangelos C Alexopoulos, MD, PhD,[6] Susanna Toivanen, PhD,[7] Anthony D LaMontagne, ScD,[8] Jean-François Chastang, PhD,[1, 2] Isabelle Niedhammer, PhD [1, 2]

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Objectives This review aimed to quantify suicide risk among agricultural, forestry, and fishery workers and study potential variations of risk within this population.

Methods We conducted a systematic literature review and meta-analysis from 1995 to 2016 using MEDLINE and following the PRISMA guidelines. A pooled effect size of suicide risk among the population of interest was calculated using meta-analysis. Subgroup analyses were conducted to investigate whether effect size differed according to population or study characteristics. Meta-regression was used to identify sources of heterogeneity.

Results The systematic review identified 65 studies, of which 32 were included in the meta-analysis. Pooled effect size was 1.48 [95% confidence interval (CI) 1.30–1.68] representing an excess of suicide risk among the population of interest. Subgroup analysis showed that this effect size varied according to geographic area, with a higher effect size in Japan. The following study characteristics were found to contribute to the between-study variance: reference group, measure of effect size, and study design.

Conclusions Our findings suggest an excess of suicide risk among agricultural, forestry, and fishery workers and demonstrated that this excess may be even higher for these groups in Japan. This review highlights the need for suicide prevention policies focusing on this specific population of workers. More research is also needed to better understand the underlying factors that may increase suicide risk in this population.

Key terms agriculture; farmer; forestry worker; occupation; systematic review; working population.

Suicide is a complex and multifactorial phenomenon in which occupation may play a role (1). Most work on the association between employment and suicide has demonstrated that being unemployed is an important risk factor for suicide at the population level (1, 2). Among working populations, some studies have shown that suicide varies according to occupation, with some occupational groups consistently having higher risk of suicide. The published research on the topic of occupation and suicide was first summarized in Bedeian's literature review (3). Although limited to three occupational groups (healthcare providers, managerial and professional persons, and military and paramilitary personnel), this review was the first to highlight that suicide rates could vary according to occupation. A decade later, Boxer et al (4) reviewed epidemiological studies on occupation and suicide published between 1982 and 1995 and suggested that some occupational groups,

1 INSERM, U1085, Research Institute for Environmental and Occupational Health (IRSET), Epidemiology in Occupational Health and Ergonomics (ESTER) Team, Angers, France.
2 University of Angers, Epidemiology in Occupational Health and Ergonomics (ESTER) Team, Angers, France.
3 Santé Publique France, Direction Santé Travail, Saint-Maurice, France.
4 University of Melbourne, Melbourne School of Population and Global Health, Centre for Health Equity, Melbourne, Australia.
5 Monash University, Turning Point, Eastern Health Clinical School, Fitzroy, Australia.
6 Occupational Health Unit, "IASO" General Hospital, Athens, Greece.
7 Stockholm University, Centre for Health Equity Studies, Stockholm, Sweden.
8 Deakin University, Centre for Population Health Research, School of Health & Social Development, Geelong, Australia.

Correspondence to: Dr. Isabelle Niedhammer, INSERM U1085, IRSET, Equipe ESTER, Rue Haute de Reculée, F-49045 ANGERS Cedex 01, France. [E-mail: isabelle.niedhammer@inserm.fr]

such as physicians, law enforcement workers, chemists and farmers, had higher risks of suicide. Like Bedeian, Boxer et al (4) highlighted the common methodological limitations of the studies included in their reviews. Most were limited to specific occupations/industries, based on small sample sizes or specific locations, did not take the potential confounding effects of age and gender into account, and suffered from a lack of accuracy in the definition of occupational groups.

Milner et al's systematic review and meta-analysis (5), published in 2013, was the first to summarize research on occupation and suicide using a rigorous methodology, going further than past narrative reviews. They found a higher risk of suicide of skilled agricultural, forestry, and fishery workers compared to the working-age population [rate ratio (RR) 1.64, 95% confidence interval (CI 1.19–2.28)]. However, their work was designed to examine the pattern of suicide risk by occupational skill level across the working population, not to specifically investigate agricultural, forestry, and fishery workers' suicide. Among the 34 studies included in their meta-analysis, for example, only 9 concerned agricultural, forestry, and fishery occupations.

The specific topic of suicide among agricultural, forestry, and fishery workers, and especially farmers, has been investigated in various narrative reviews. Kennedy et al (6) underlined the higher suicide rates among farmers compared to other occupational groups and suggested different patterns of suicide within this population. Their work has limited generalizability, however, as they considered studies originating from Australia or discussing the Australian context only. Farmers' suicide has also been investigated in the broader context of rural suicide, as most farming activities occur in rural areas (7, 8), or in reviews addressing farmers' mental health, as mental disorders are one of the main risk factors for suicide (9–11). These reviews agreed on the fact that the literature consistently reported a higher risk of suicide among farmers. Several limitations should be considered when interpreting the findings of these narrative reviews. First, they did not use systematic methods to locate all relevant literature (7–11). Many also had a limited scope in terms of either geographical area (UK (10), Australia (7, 8)), or gender (male suicide only) (8, 11). Finally, some adopted a sociological more than an epidemiological approach (8). To our knowledge, the topic of suicide among agricultural, forestry, and fishery workers has not been previously investigated through systematic review and meta-analysis and there has been no previous literature review on suicide among forestry and fishery workers exclusively.

Our objectives were therefore to summarize the epidemiological evidence to date on suicide among farmers, and more widely among agricultural, forestry, and fishery workers, by: (i) quantifying the risk of suicide among agricultural, forestry, and fishery workers as compared to the general working population using a meta-analysis, and (ii) investigating potential variations of risk within this population according to occupational and sociodemographic characteristics.

Methods

Search strategy

This review on suicide mortality among agricultural, forestry, and fishery workers was based on a systematic search conducted using the MEDLINE/PubMed database in July 2016. The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (www.prisma-statement.org). Two broad categories of studies provide information on suicide mortality among agricultural, forestry, and fishery workers and were eligible for inclusion: (i) studies examining suicide according to occupation, and (ii) studies that focus specifically on suicide within this group. Keywords were selected to capture these two categories of studies (table 1). To check the comprehensiveness of the studies retained, reference lists of prior literature reviews, as well as the most recent papers, were also examined for studies inadvertently missed by the electronic search.

Inclusion criteria, eligibility and selection of studies

To be considered eligible for inclusion in the systematic review, studies had to: (i) include the keywords in the abstract or title; (ii) be written in English or French, and (iii) be published from 1995 to 5 July, 2016. Studies focused on a non-working population (unemployed, elderly, youth, prisoners, etc.) or outside work risk factors for suicide were excluded, as were studies focusing on suicide attempts, assisted suicide or one specific suicide method (suicidal pacts, suicide by pesticide ingestion, etc.). Studies concerning suicide prevention, management of suicide attempts, or compensation were

Table 1. Keywords used in the search strategy.

Exposure	Outcome
Agriculture, agricultural	Suicide
Farmer(s), farm(s), farming	Self-harm
Farmworker(s)	Self harm
Fishery, fisherman, fishermen	
Forestry	
Job(s)	
Work; working, worker(s)	
Occupation(s), occupational	
Employment, employee(s), employed	

also excluded. Studies analyzing suicide among one occupation/sector not related to agricultural, forestry, and fishery workers (suicide among health professionals for example) or studies not including agricultural, forestry, and fishery workers among the analyzed occupations were also excluded. Case reports, qualitative studies, reviews, letters, comments and ecological studies were excluded to leave only quantitative individual epidemiological studies.

Only studies from Europe, North America, Australia, New Zealand and Japan were retained because of strong differences in patterns of suicide and in agricultural, forestry, and fishery industries and occupations between high-income countries and low/middle-income countries. Studies were also excluded if no quantitative results were presented for agricultural, forestry, and fishery workers. Of the studies included in the overall systematic review, only those providing a suicide effect size with its 95% CI comparing agricultural, forestry, and fishery workers to a reference population (which could be the general or working population) were included in the meta-analysis.

Two of the authors (JK and IN) conducted the systematic search, study screening, and selection independently. In case of inconsistencies, classification mismatches were discussed and resolved by consensus. Figure 1 displays the selection process.

Data extraction

Two of the authors (JK and IN) independently extracted data using a standardized form and resolved discrepancies by consensus. Information extracted included first author name, journal, publication date, study design, geographic location of the study population, time period, gender, number of occupations investigated, definition of the population of interest (agricultural, forestry, and fishery workers), reference group, suicide measure, data source, and results. Extracted data from studies included in the meta-analysis are presented in supplementary table S1 (www.sjweh.fi/show_abstract.php?abstract_id=3682).

The definition of the population of interest remains challenging (12) and the term "farmer", and related synonyms (farm or agricultural worker, farm or agricultural

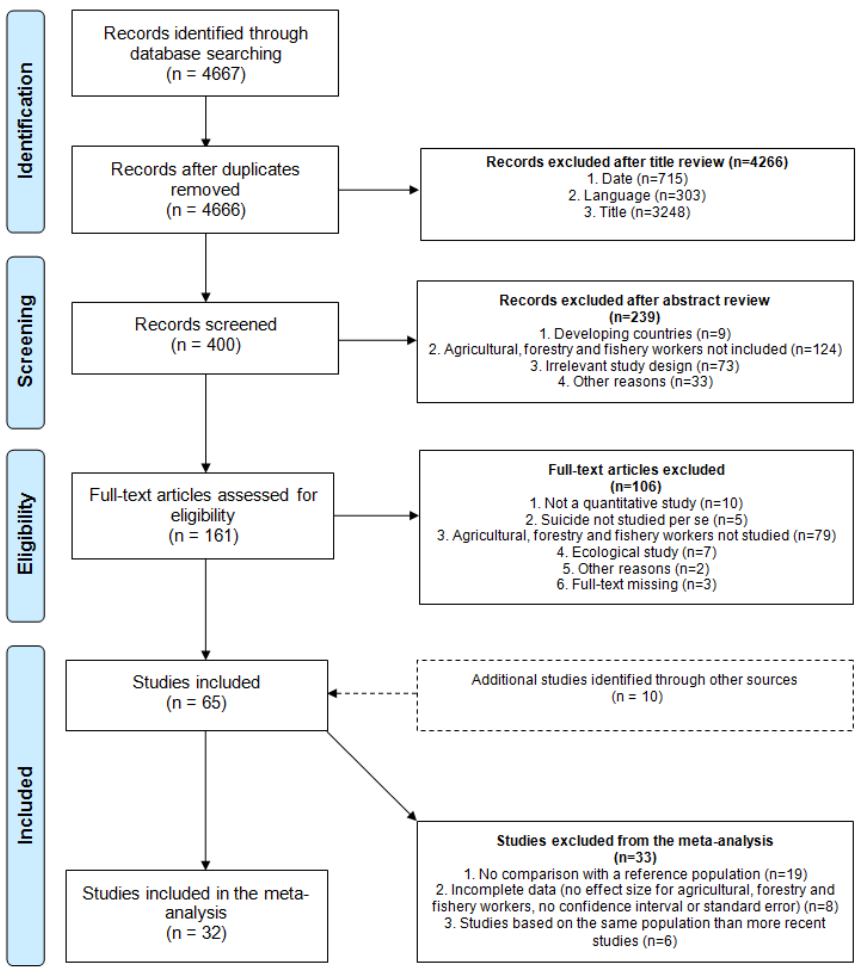

Figure 1. Selection process of studies for meta-analysis.

laborer, farm manager, etc.), are often used but not well defined, making the definition of the population studied ambiguous and the comparison between studies difficult. In this review, the terms used by the authors of the studies included in the meta-analysis are presented in table S1. If available, additional information on the content and definition of the terms used to characterize the population is also provided (table S1). To enable subgroups analyses and comparisons across studies, workers considered in each study were assigned to one of the following groups: (i) all sectors, ie, agriculture, fishery, and forestry; (ii) agriculture; (iii) fishery; (iv) forestry; or (v) mixed sectors (for example, agriculture and fishery). If the detail provided in the article was insufficient to determine the appropriate population for any one study, we adopted the standard classification of occupations used by the authors to allow unambiguous classification. If doubt persisted, workers were assigned to the broadest category (ie, agriculture, fishery, and forestry).

When presenting and discussing the results of our meta-analysis, we used the following terms: (i) "agricultural, forestry, and fishery workers" for the whole population of interest, (ii) "self-employed workers" and "employees" to provide information on work status, (iii) "laborers" to define low-skilled workers, and (iv) "agriculture, forestry, and fishery" to define the three main sectors. This terminology is consistent with the International Standard Classification of Occupation (ISCO- 2008).

Meta-analysis, subgroup analyses and meta-regression

The meta-analysis was performed using the studies providing a suicide effect size with its 95% CI among agricultural, forestry, and fishery workers. As several studies concerned the same study population, only the most recently published study or the study providing the information useful for the meta-analysis was considered to retain only independent samples. Six studies were excluded for this reason (13–18), as they were duplicates of the following studies (19–24). The effect sizes assessed in the meta-analysis included proportional, comparative, or standardized mortality ratio (PMR, CMR, SMR), odds-ratio (OR), hazard ratio (HR), relative risk or rate ratio (RR). For 23 studies, we asked the authors (22 authors) for additional results (age-adjusted suicide RR or other estimates and CI for agricultural, forestry, and fishery workers with all other occupations together as a reference group, and separately for men and women). Of the 23 studies, 2 were included in the meta-analysis using additional results provided by the authors (25–27), 7 were included in the meta-analysis using the results available in the publication (23, 28–33), 6 were included in the meta-analysis using results that we calculated from raw data of the publications (34–39), and 8 were not included in the meta-analysis (21, 40–46). If a study provided more than one effect size for the same population according to various time periods, information concerning the largest or most recent time period was preferentially extracted. If a study provided more than one effect size using different models, the results adjusted for age or the least adjusted results were retained, as the most frequent adjustment used in the studies was age or no adjustment. If a study provided various effect measures, RR, OR, or SMR were chosen following this order of preference. If a study did not provide any effect size and/or 95% CI, raw data were used to calculate an unadjusted OR and its 95% CI. If agricultural, forestry, and fishery workers were the reference group in multivariate analysis, effect sizes and CI were recalculated using another occupational group (preferentially a high-skilled occupational group) as a reference.

A pooled effect size was calculated, representing the risk of suicide among agriculture, forestry, and fishery workers compared to a reference population. Stratified analyses were conducted and produced pooled effect sizes according to (i) population characteristics: gender (male, female, both genders combined), geographic area (Europe, Oceania [ie, Australia and New Zealand], North America [ie, USA and Canada], and Asia [ie, Japan]), and sector (agriculture, forestry, fishery, mixed sectors, all sectors), and (ii) study characteristics: study design (routine data, prospective study, other study design), effect measure (CMR, SMR, PMR, OR, RR, HR), reference group (general population, all occupational groups, all other occupational groups, one specific occupational group), and adjustment (unadjusted, age-adjusted, more than age-adjusted results). The following selection rules were adopted: (i) if a study provided various effect sizes according to gender (both genders, men, and women), the results for men and women separately (and not the whole sample of both genders) were retained in order to examine potential differences between genders; (ii) if a study provided various effect sizes for nested occupational groups (for example agriculture alone and agriculture, fishery, and forestry), only the effect size of the broadest group was retained. Heterogeneity between studies was investigated through the I-squared (I^2) statistic. As between-study heterogeneity was expected to be large, we used the random effects model (DerSiminonian-Laird). Random effects meta-regression was used to assess the extent to which statistical heterogeneity between studies was explained by population and study characteristics.

Sensitivity analysis

A sensitivity analysis was conducted to test the robustness of the results. We excluded four studies that defined the population of interest on the basis of the exposure to chemicals (pesticides) rather than job title (20, 24,

30, 47) and one study that considered persons residing, rather than just those working, on agricultural establishments (39).

Funnel plots

A funnel plot was used to investigate the presence of small study effects.

All analyses were performed using Stata for Windows, version 14, (Stata Corp, College Station, TX, USA) using the *metan* suite of commands (48).

Results

Among the 65 studies eligible for inclusion in the systematic review, 32 were included in the meta-analysis (19, 20, 22–26, 28–39, 47, 49–60).

Characteristics of studies included in the meta-analysis

Most of the studies included in the meta-analysis were conducted in English-speaking countries: including Australia and New Zealand (N=8) (20, 29, 35, 39, 49, 50, 52, 58), the United States and Canada (N=8) (24, 30, 34, 36, 38, 47, 57, 60), and the United Kingdom (N=5) (19, 22, 33, 54, 56). Others originated from European Nordic countries (N=5) (26, 28, 37, 53, 59), France (N=2) (51, 55), Japan (N=2) (23, 31), and Greece (N=1) (25). One study was based on both French and Spanish samples (32).

Of the 32 studies, 20 analyzed suicide among men and women, 12 focused on male suicides only (19, 20, 22, 23, 32–34, 43, 52, 59–61). No study examined female suicide exclusively.

The population of interest (agricultural, forestry, and fishery workers) was mixed and included workers from various sectors, and work statuses (employees, self-employed). The agriculture sector was the most studied (19 studies). Only 2 studies provided results for fishery workers (22, 57) and 3 for forestry workers (19, 22, 57). The other studies explored the population of interest from various sectors simultaneously.

The majority of studies (N=21) defined the population of interest using standard classifications of occupations (ISCO or national classifications). Four studies defined the population of interest on the basis of exposure to pesticides rather than job title (20, 24, 30, 47). Although the definition of pesticide workers is not strictly similar to the definition of agricultural, fishery, and forestry workers, there may be a strong overlap between the two groups. We therefore retained these studies in our review.

In most studies, deaths from suicide were identified from national mortality registries using the causes of death codes from the International Classification of Diseases. Five studies used a broader definition including undetermined deaths from injury and/or poisoning irrespective of whether they were accidentally or purposely inflicted (19, 22, 33, 56, 58).

The majority of studies used routinely collected data on mortality and occupation (N=20): national mortality registers providing information on the cause of death are typically linked to sociodemographic or occupational information obtained through national census or registries. Five studies used a prospective cohort design (35, 36, 55, 57, 59). Other designs included case–control or exposed/non exposed study designs (19, 20, 28, 30, 33, 47, 53).

The studies used different measures of association: one used CMR (25), three used PMR (19, 22, 54), eight used SMR (24, 47, 52, 53, 55, 56, 58, 60), two used HR (26, 59), three used OR (20, 30, 31) and nine used RR (23, 28, 29, 32, 33, 49–51, 57). For five studies, we calculated OR and 95% CI and, for one study, we calculated RR and the 95% CI from raw data (34–39). All these measures were considered comparable for the meta-analysis as suicide is a very rare outcome (62).

Each study compared suicide mortality of agricultural, forestry, and fishery workers to a reference group. The general population was the reference group in nine studies (19, 24, 34, 39, 47, 52, 53, 55, 56). Seven studies compared suicide among the agricultural, forestry, and fishery workers to all occupational groups, including the group of interest (22, 25, 49, 54, 57, 58, 60). Nine studies compared suicide mortality to all occupational groups, except agricultural, fishery and forestry workers (ie, all other occupational groups) (20, 26, 30, 33, 35, 37, 38, 50, 59). Seven studies used one specific occupational group as a reference group (23, 28, 29, 31, 32, 36, 51).

For the majority of studies, the results were provided with no adjustment (N=13) or were adjusted for age only (N=10). The remaining studies used multiple adjustment (N=9) (24, 28, 30, 31, 33, 47, 51, 54, 55).

Overall results and stratified analysis

The overall pooled effect size from the 32 studies included in the meta-analysis was 1.48 (95% CI 1.30–1.68), showing a significant excess of risk of suicide among agricultural, forestry, and fishery workers. The overall results are presented in figure 2.

Stratified analysis (figure 3) showed that males had a pooled effect size of 1.50 (95% CI 1.30–1.72) and females had a pooled effect size of 1.33 (95% CI 0.85–2.08). These results did not differ significantly between genders and gender did not explain the heterogeneity

between studies. Geographical area explained 22.9% of the heterogeneity between studies, with studies from Japan demonstrating a significantly greater excess of risk of suicide in these occupations than those originating from other georgraphic areas. Analysis according to sector found that all sectors had a significant excess of suicide risk except for the fishery sector, but the number of studies for this sector was low. There was no significant difference between sectors, and sector did not explain the between-study variance.

Regarding study characteristics, reference group contributed substantially to heterogeneity (I^2 = 35.8%); studies in which reference group was one specific occupation were more likely to find elevated effect sizes

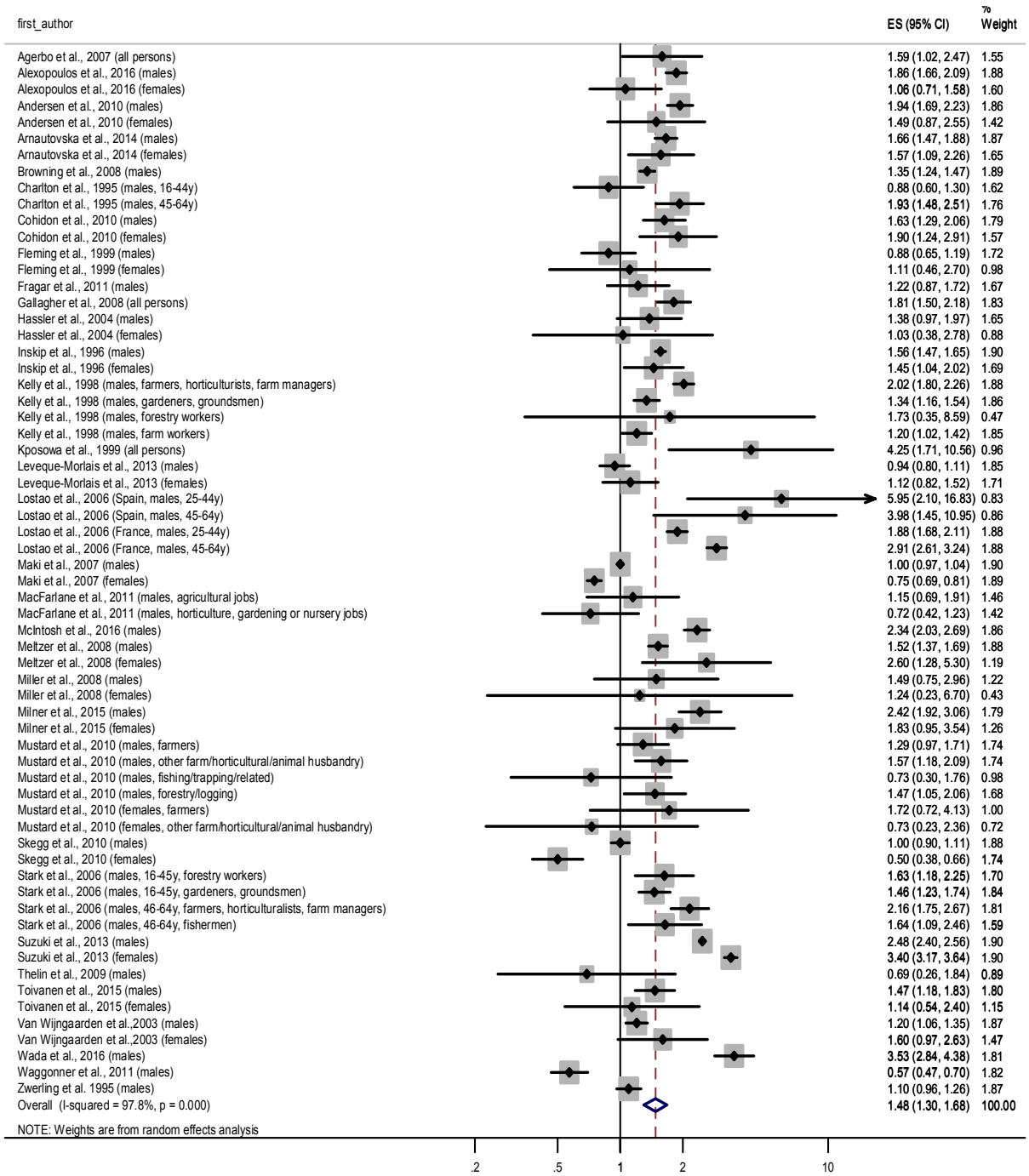

Figure 2. Results of global meta-analysis of suicide among agricultural, forestry and fishery workers.

than all other studies. The measure of effect size also explained 22.7% of between-study variance; studies using RR produced higher effect sizes and the studies using SMR produced lower effect sizes. Study design also contributed to the explanation of the between-study variance (I^2 = 10.8%) with studies using routine data being more likely to find greater effect sizes than others. Adjustment type did not explain any heterogeneity.

Sensitivity analysis

Pooled effect size obtained from the sensitivity analysis was 1.56 (95% CI 1.36–1.78), which supported the robustness of our results.

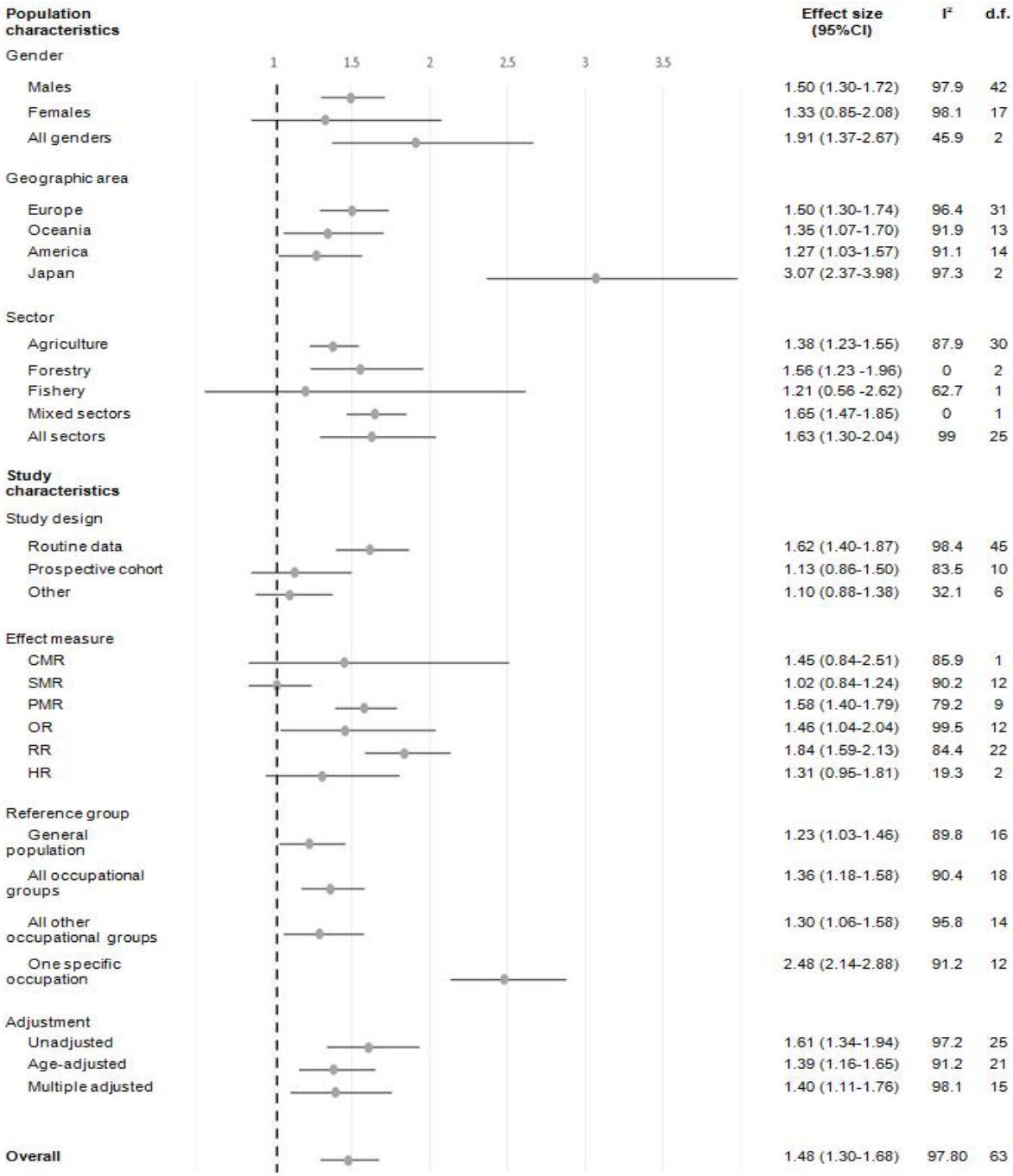

Figure 3. Results of stratified meta-analysis of suicide among agricultural, forestry and fishery workers with studies classified according to population and study characteristics.

Funnel plot

A funnel plot showed that most of the studies had small standard errors (figure 4). Its shape was symmetrical, and Egger's test for publication bias was not significant. These results indicated no evidence of small study effects and suggested that our results are unlikely to have been affected by publication bias.

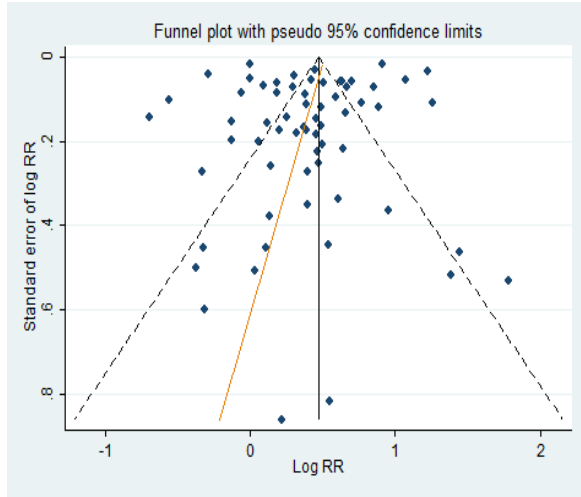

Figure 4. Funnel plot.

Discussion

Main findings

Our systematic review and meta-analysis of suicide among agricultural, forestry, and fishery workers identified 65 studies, 32 of which were included in the meta-analysis. Our results quantified the excess of suicide risk in this population (pooled effect size 1.48, 95% CI 1.30–1.68), in agreement with the results from the only previous meta-analysis by Milner et al (RR 1.64, 95% CI 1.19–2.28) based on a far smaller number of nine studies (5). Pooled effect sizes by gender, geographic area, and sector were also calculated and showed that suicide risk varied within this population of workers. Agricultural, forestry, and fishery workers from Japan had an even greater elevated suicide risk (pooled effect size 3.07, 95% CI 2.37–3.98) compared to those from other geographic areas, but this result was based on two studies only. Heterogeneity between studies was mainly explained by study characteristics (reference group, measure of effect size, and study design).

Possible explanations

Various hypotheses are raised by the literature to explain the excess of suicide risk among agricultural, forestry, and fishery workers.

The influence of work-related factors, notably access to lethal means, is largely discussed. A recent study by Milner at al (63) showed that work-related access to means was a risk factor for suicide in the employed population. They found that persons in occupations with access to specific methods (firearms, medicine or drugs, and carbon monoxide) were more likely to use these methods to end their lives than those without access to means (63). Through their work, agricultural, forestry, and fishery workers have easy access to lethal agents (weapons, toxic substances, etc.), and several studies have showed that suicide by firearm is the leading method of suicide in farmers although this method remains scarce in the general population (21, 34, 43, 58, 64, 65). Knowledge of, and easy access to, lethal means is similarly reported to explain high suicide rates found among healthcare or military personnel (56, 66, 67). Another work-related factor that may contribute to elevated suicide risk is the exposure to toxic substances, especially pesticides. In low/middle-income countries, suicide involving pesticides has been largely reported among farmers, especially in Asia, including Western Pacific and South East Asia regions (68). In high-income countries, some studies found an association between high pesticide exposure or poisoning and risk of psychiatric disorders (including suicidal behavior) (20, 21, 69, 70). However, Beard et al (71), for example, found no association between moderate pesticide use and suicide in a large cohort of pesticide applicators and, according to a recent systematic review, scientific evidence of the association between pesticide exposure and either depression or suicide is still inconclusive (72).

Through their work, agriculture, fishery, and forestry workers may be involved in ending the lives of animals. This repeated exposure to death, according to Joiner's interpersonal theory of suicidal behavior (73), may result in habituation and a sense of fearlessness in the face of death that can lower inhibitions about suicide. Witte et al's findings supported this theory: in a study among veterinarians, they found a positive relationship between experience with euthanasia and fearlessness about death that may be due to emotional habituation to the process of euthanasia (74).

Other factors likely to influence suicide rates among agriculture, fishery, and forestry workers include long working hours, social isolation, physically demanding work, and high levels of occupational stress due to unpredictable natural events and weather conditions (excess or lack of sun light and rain, temperature changes, etc.) (75) exacerbated by climate change (8). One study conducted in a cohort of sawmill workers

showed that low psychological demands at work were associated with an elevated risk of dying by suicide (76). This suggests that, although psychosocial job stressors have been, to date, poorly investigated in the topic of suicide among agriculture, fishery, and forestry workers, they warrant further investigation.

Individual characteristics may also explain an elevated suicide risk among agriculture, fishery, and forestry workers. Psychiatric disorders play a central role in suicide (77), and the question of whether these workers have higher rates of psychiatric disorders compared to the general population has been investigated (7, 9). The most recent studies on this topic suggest that agriculture, fishery, and forestry workers have a higher risk of mental health problems and psychiatric disorders than the general population (78–80). Personality factors, for instance self-reliance among men (81), have also been found to be associated with suicidal behavior. These factors may lead to a selection effect into farming or other agriculture-related jobs and thus could increase the risk of suicide in this population. Studies have also raised the role of cultural factors to explain excess of suicide among agriculture, fishery, and forestry workers. Booth et al (65) suggested differences in help-seeking behavior for mental health concerns between farmers and the general population, and found that farmers were more likely to present with physical problems when depressed. This may result from a lack of knowledge of, or stigma against, psychiatric disorders among this population. In line with these findings, Alston et al (8) raised the role of a distinct conception of masculinity existing in rural areas, based on individualism and stoicism, which may make rural men unwilling or unable to seek help for mental health problems. Furthermore, rural locations, where most of the agriculture-related activities take place, may have no or limited access to mental health services, and finding time to leave the farm can be challenging (8).

Other assumptions, related to social, economic and structural changes occurring in rural and regional areas of high-income countries within recent decades could be made: increasing global competition; a decline in the number of farms; the move towards more industrial farming with bigger units, more efficiency, specialization, and volume of production; a drop in agricultural food commodities prices; the replacement of agricultural workforce by machines, leading to important demographic changes (agricultural outmigration); and difficulties arising from the European Union (Common Agricultural Policy implementation) may have impacted farmers' work and lifestyle negatively. Apart from one ecologic study that found no association between agricultural rationalization in post-war Europe and increased suicide rates (82), these aspects have been little studied in epidemiology.

Strengths and limitations

Our results built on those of previous reviews in several ways. This is, to our knowledge, the first review that used systematic review and meta-analysis to investigate suicide among agriculture, fishery, and forestry workers. The study protocol was based on the PRISMA guidelines. Another strength of our study is related to our attempt to study various subgroups of this population according to gender, geographic area, and sectors of agriculture, fishery, and forestry, highlighting differences within this population, something that has not been previously published. We placed an emphasis on the definition of the population of interest and referred as much as possible to ISCO. Most of the studies reviewed used death certificates and International Classification of Diseases to investigate and code suicide mortality. This is considered as a high quality method providing the best available measure of suicide mortality.

A number of limitations should, however, be mentioned. First, we conducted our literature search using MEDLINE only. As our objective was to study mortality and more especially suicide based on quantitative epidemiologic studies, MEDLINE may be considered as the appropriate reference base. In addition, we checked the comprehensiveness of our references by exploring other sources (reference lists from other literature reviews and recent publications) to identify potentially eligible studies inadvertently missed by the electronic search. Eight studies were excluded from the meta-analysis because they did not provide effect-size measures with CI. However, most of these studies reported a higher risk of suicide among agriculture, fishery, and forestry workers, although no statistical testing was performed. The exclusion of these studies is therefore unlikely to have changed our results substantially. There may also be weaknesses related to the limitations of the studies included in our review. Our sector variable may suffer from a lack of precision and misclassification may have occurred due to the absence of definition or details provided by some studies about the population of interest. Death certificates are considered as an objective and accurate source of information. However, underreporting of suicide may occur (1) mainly for methodological reasons: some deaths such as accidents, drug overdoses, drowning may be suspected as suicides but not classified as such due to doubt of the intent. Another limitation is that our meta-analysis pooled together studies that may be different according to the population studied and methodological aspects of the study (definition of the outcome, study design, reference group, effect measure, etc.). Consequently, high levels of heterogeneity were found. Meta-regression showed that the highest proportion of heterogeneity between studies came from the use of different reference groups. Studies using one specific

occupational group as a reference were significantly more likely to find greater effect sizes than others. As the occupational group selected as a reference was often the group of minimal suicide risk (ie, higher skilled occupational groups such managers and/or professionals), it is straightforward that those studies were able to show greater effects. Type of effect measure also explained an important part of heterogeneity. We grouped together studies reporting HR, which includes variability in time at risk, with studies reporting other static effect size measures. However, HR were reported in two studies only (26, 59) and we found no overall difference in the magnitude of the effect size between these measures and the other static measures of association reported in the remaining studies included in the analysis.

Recommendations for further research

Most previous studies examined suicide risk among the agriculture, fishery, and forestry workers as a whole or focused on a very specific subgroup, such as farmers. Some studies, however, suggested that suicide patterns may vary among different subgroups of agriculture, fishery, and forestry workers (43, 83). For instance, Page et al (43) showed that the majority of suicide deaths among farm laborers occurred in the 15–39-year-old age group, whereas farm managers who died by suicide were older (≥55 years) suggesting that risk factors may vary according to work status. To better characterize risk variations within this population, some elements may be worth researching further. We initially planned analyses according to work status (self-employed workers versus employees). This could not be done because only one study provided results disaggregated in this way (26, 27). Similarly, we planned analyses according to skill levels (for example, managers versus laborers), but no study provided separate results by occupational skill level. This is probably related to the difficulty of classifying this population into the ISCO or other national classifications. Indeed, they may fall into two different major groups: the ISCO major group 6 "skilled agricultural, forestry, and fishery workers" or the ISCO major group 9 "elementary occupations", which includes a subgroup of "agricultural, forestry, and fishery laborers" (code 92). Other subgroups of agriculture, fishery, and forestry workers may have been relevant to study in relation to suicide risk, for example, seasonal versus permanent workers. As noted by Fraser et al (9), although seasonal and migrant workers face the same health and safety risks as permanent workers, they are poorly investigated in epidemiological studies. It would also have been interesting to compare suicide mortality among full- versus part-time workers. Unfortunately, only one study (59) considered the time spent farming (>25 hours per week) when selecting its study population. Ultimately, as we found that a majority of studies focused on the agriculture sector and males, female suicide and suicides in the forestry and fishery sectors should also be further investigated.

Concluding remarks

Although a number of studies provided information about an elevated suicide risk among agriculture, fishery, and forestry workers, this excess had never been quantified and explored thoroughly through a systematic review and meta-analysis. The present findings support the existence of an excess suicide risk among this population and further demonstrated that this risk varied according to geographic area. Future research is needed to clarify whether this risk may vary according to other sociodemographic and occupational characteristics, such as age, work status or skill level. In future studies, more attention should be given to the definition of the population of interest and the use of ISCO terminology to enable more precise comparisons between studies. Suicide prevention policies focusing on this population of workers may be needed.

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