

**Association of food insecurity with suicidal ideation and suicide attempts in adults aged  
≥50 years from low- and middle-income countries**

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## **ABSTRACT**

**Background:** The aim of the present study was to investigate associations between food insecurity with suicidal ideation and suicide attempts in adults aged  $\geq 50$  years from six low and middle-income countries (LMICs). **Methods:** Cross-sectional, community-based data from the World Health Organization's Study on Global Ageing and Adult Health were analyzed. Self-reported information on past 12-month suicidal ideation and suicide attempts was collected. Past 12-month food insecurity was assessed with two questions on frequency of eating less and hunger due to lack of food. Multivariable logistic regression analysis was conducted to assess the association between food insecurity and suicidal ideation or suicide attempts. **Results:** The final analytical sample included 34,129 individuals aged  $\geq 50$  years [mean (SD) age 62.4 (16.0) years; 52.1% females]. Compared to no food insecurity, severe food insecurity was associated with a significant 2.78 (95%CI=1.73-4.45) times higher odds for suicidal ideation, while moderate and severe food insecurity were associated with 2.59 (95%CI=1.35-4.97) and 5.15 (95%CI=2.52-10.53) times higher odds for suicide attempts, respectively. **Limitations:** The cross-sectional design, the use of self-reported wish to die as a measure of suicide ideation, and that suicidal ideation and suicide attempts were only assessed among those who had depressive symptoms, could be considered limitations of our study. **Conclusions:** Food insecurity was positively associated with suicidal ideation and suicide attempts. Targeting food insecurity among older adults in LMICs may lead to reduction in suicidal ideation and suicide attempts, although future longitudinal studies are warranted to confirm this.

## INTRODUCTION

Globally, approximately 800,000 people die from suicide each year and 79% of global suicides occur in low- and middle-income countries (LMICs) (World Health Organisation, 2021). Previous research has indicated that older adults are at higher risk of suicide compared to younger adults (De Leo et al., 2002). Concerningly, a study of global suicide rates found that suicide rates increase with age over the age of 60 (Shah et al., 2016).

A suicide attempt may be defined as a nonfatal self-directed potentially injurious behavior with any intent to die as a result of the behavior (O'Connor et al., 2013), and is considered to be the single most important risk factor for completed suicides (Naghavi, M., 2019). Suicidal ideations include contemplations, wishes, and preoccupations with death and suicide (Harmer, B., 2021). Importantly, suicidal ideations often precede suicide attempts (Harmer, B., 2021<sup>a</sup>). Interestingly, the prevalence of suicidal ideation varies across populations of older adults, ranging from 0.7% in older primary care patients to 26% in acute medically ill older adult inpatients (Callahan, C. M et al., 1996; Shah, A et al., 2000). In a recent study which examined suicidal ideation and behavior within community and health facility settings across five LMICs (Ethiopia, Uganda, South Africa, India, and Nepal), 10.3% of the sample presenting at primary care facilities reported suicidal ideation within the past twelve months, and 2.2% of the sample had attempted suicide in the same period. Within the community samples, the prevalence of suicidal ideation ranged from 3.5% to 11.1%, however suicidal ideation was more prevalent in the primary care facility samples, and ranged from 5.0% to 14.8% (Jordans, M., et al. 2018). This is of particular importance as suicides are more prevalent in LMICs (World Health Organisation, 2021).

It is clear that intervention and policy are needed to curb the high prevalence of suicidal ideation and suicide attempts among older adults in LMICs, as this may also ultimately lead to reduction in completed suicides. However, to develop future intervention and policy, further research is required to identify the correlates of suicidal ideation and suicide attempts among older adults in LMICs. Several correlates of these have already been identified in older adults and include physical diseases, mental health complications, sleep difficulties, mobility restrictions, poorer quality of life, and severe functional limitations. (Smith, L et al., 2021; Callahan CM et al., 1996; O'Riley AA et al., 2014; Liao SJ et al., 2018; Sirey JA et al., 2008; Murat A et al., 2019; Conejero I et al., 2018; Chiu HF et al., 2012). However, one understudied but potentially important correlate is that of food insecurity.

Food insecurity may be defined as limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire food in socially acceptable ways (Bickel G et al., 2000). Food insecurity may increase risk for suicidal thoughts and behaviors through multiple pathways. For example, inadequate nutrition, stress, and stigma associated with food insecurity, could result in poorer mental health which increases the risk for suicides and related behavior. Moreover, food insecurity in older adults has been associated with frailty (Jones A., 2017), and this condition is positively associated with suicidal behaviors (Bickford D et al., 2021).

Despite this, only a small literature base exists exploring the association between food insecurity and suicidal thoughts or behavior, with all adult studies being conducted in high-income countries, while the only study from a LMIC focused solely on adolescents (Shayo FK et al., 2019). Specifically, one cross-sectional study conducted in Canada (n = 5,270) found that among adults aged 18 years and over, suicidal ideation was significantly

associated with moderate and severe food insecurity (Davison KM et al., 2015). In another study, which used a nationally representative sample of U.S. adults (n = 288,730), it was found that those included in the Supplemental Nutrition Assistance Program had a greater prevalence of suicide-related outcomes compared to those not included (Bergmans RS et al., 2020). Finally, one study consisting of 179,771 adolescents from 44 countries including LMICs found that hunger is a global problem, which is associated with higher odds for suicide attempts among adolescents (Koyanagi, A., et al., 2019).

However, to our knowledge, no studies exist which focus on older adults and specifically older adults who reside in LMICs. This is of importance as food insecurity is common in LMICs (Smith, MD., & Meade, B., 2019) and the prevalence of both food insecurity and suicide is high among older adults (Pirrie, M et al., 2020; De Leo D et al., 2002). Therefore, the aim of the present study was to investigate the associations of food insecurity with suicidal ideation and suicide attempts in a sample of 34,129 individuals aged  $\geq 50$  years from six LMICs (China, Ghana, India, Mexico, Russia, South Africa).

## **METHODS**

### ***The survey***

Data from the Study on Global Ageing and Adult Health (SAGE) were analyzed. These data are publicly available through <https://www.who.int/data/data-collection-tools/study-on-global-ageing-and-adult-health>. This survey was conducted in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and 2010. Ghana was classified as a low-income country, and China and India were classified as lower middle-income countries, while the remaining countries were classified as upper-middle income countries based on the World Bank Classification at the time of the survey.

A multistage clustered sampling design method was used to collect data from a nationally representative sample of adults aged  $\geq 18$  years, with oversampling of those aged  $\geq 50$  years. Face-to-face interviews were conducted by a trained interviewer, and a standard translation was used to ensure consistency across countries. Response rates ranged across countries with the highest response rate in China (93%), and the lowest response rate in Mexico (53%). To adjust for the population structure as reported by the United Nations Statistical Division, sampling weights were constructed. Further details of the survey methodology have been published elsewhere (Kowal P et al., 2012).

### ***Ethical approval***

Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards (Shanghai Municipal Centre for Disease Control and Prevention, Shanghai, China; Ghana Medical School, Accra, Ghana; International Institute of Population Sciences, Mumbai, India; National Institute of Public Health, Cuernavaca, Mexico; School of Preventive and Social Medicine, Russian Academy of Medical Sciences, Moscow, Russia; and Human Sciences Research Council, Pretoria, South Africa). Written informed consent was obtained from all participants.

### ***Suicidal ideation and suicide attempts***

The assessment of suicidal ideation and suicide attempts was guided by previous SAGE publications (Cabello M et al., 2020; Ghose B et al., 2019; Smith L et al., 2021), using a modified version of the depression module of the WHO Composite International Diagnostic Interview (Kessler RC & Ustun TB., 2004). Individuals who screened positive in the depression module were asked further questions relating to suicidal thoughts and behavior.

To be identified as a positive screen, participants had to report having a minimum of one of the three following conditions for longer than two weeks in the past 12 months: sadness, loss of interest, or low energy. To identify suicidal ideation, participants were asked “Did you think of death, or wish you were dead?” and to identify suicide attempts, participants were asked “During this period, did you ever try to end your life?” with ‘yes’ and ‘no’ answer options (Cabello M et al., 2020; Ghose B et al., 2019).

### ***Food insecurity***

Food insecurity was defined by the two following questions: “In the last 12 months, how often did you ever eat less than you felt you should because there wasn’t enough food?” and “In the last 12 months, were you ever hungry, but didn’t eat because you couldn’t afford enough food?” Both of these questions had as response options: every month (coded=1); almost every month (coded=2); some months, but not every month (coded=3); only in 1 or 2 months (coded=4); never (coded=5). These items were based on similar items found in food security questionnaires such as the US Household Food Security Survey Module and National Health and Nutrition Examination Survey (NHANES) Food Security module. As in a previous SAGE study, those who answered 1 through 3 to both questions or answered 1 to either item were categorized as severely food insecure. Those who did not fulfill the criteria for severe food insecurity but answered 2 through 4 for either question were coded as moderately food insecure. Those who answered 5 to both items were categorized as food secure (Schrock JM et al., 2017). We also used the dichotomous variable of any food insecurity (i.e., moderate/severe or none) in some analyses.

### ***Control variables***

Control variables were selected based on their previously reported association with food insecurity and suicidality (Montgomery J et al., 2017; Reitzel LR et al., 2020; Smith L et al., 2021; Borges G et al., 2017), and included sex, age, wealth quintiles based on income, years of education received, unemployment (engaged in paid work  $\geq 2$  days in last 7 days: Y/N), smoking (never, current, past), alcohol consumption in the past 30 days (Y/N), physical activity, and poor self-rated health (Y/N). Levels of physical activity were assessed with the Global Physical Activity Questionnaire and were classified as low, moderate, and high based on conventional cut-offs (Bull FC et al., 2009). Self-rated health was evaluated by the question ‘In general, how would you rate your health today?’ Those who answered ‘bad’ or ‘very bad’ were considered to have poor self-rated health.

### ***Statistical analysis***

Statistical analysis was performed with Stata 14.1 (Stata Corp LP, College station, Texas).

The analysis was conducted among adults aged  $\geq 50$  years. Difference in sample characteristics between those with and without any food insecurity was tested by Chi-squared tests and Student’s *t*-tests for categorical and continuous variables, respectively.

Multivariable logistic regression analysis was done to assess the association between the three-category food insecurity variable (i.e., none, moderate, severe) (exposure variable) and suicidal ideation or suicide attempts (outcome variables) using the overall sample. We also conducted an analysis with “isolated suicidal ideation” as the outcome by excluding people who reported a suicide attempt from the analysis (Devyllder JE et al., 2015). Furthermore, in order to assess whether there is between-country heterogeneity in the association between any food insecurity (i.e., moderate/severe food insecurity) and suicidal ideation or suicide attempts, we conducted country-wise multivariable logistic regression analysis and calculated



the Higgins's  $I^2$  based on estimates from each country. The Higgins's  $I^2$  represents the degree of heterogeneity that is not explained by sampling error with a value of <40% often considered as negligible and 40-60% as moderate heterogeneity (Higgins & Thompson, 2002). A pooled estimate was obtained by fixed-effect meta-analysis. All regression analyses were adjusted for sex, age, wealth, education, unemployment, smoking, alcohol consumption, physical activity, self-rated health, and country, with the exception of the country-wise analyses which were not adjusted for country. Adjustment for country was done by including dummy variables for each country in the model as in previous SAGE publications. All variables were included in the models as categorical variables with the exception of age and education (continuous variables). The sample weighting and the complex study design were taken into account in the analyses to obtain nationally representative estimates. Results from the regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at  $P < 0.05$ .

## RESULTS

The final sample included 34,129 individuals aged  $\geq 50$  years (China  $n=13,175$ ; Ghana  $n=4,305$ ; India  $n=6,560$ ; Mexico  $n=2,313$ ; Russia  $n=3,938$ ; South Africa  $n=3,838$ ). Sample characteristics are presented in **Table I**. Overall, the mean (SD) age was 62.4 (16.0) years and 52.1% were females. The overall prevalence of moderate and severe food insecurity were 6.7% and 5.1%, respectively, while those of suicidal ideation and suicide attempts were 3.4% and 0.6%, respectively. The prevalence of suicidal ideation, suicide attempts, females, lower levels of wealth, current smoking, high level of physical activity, and poor self-rated health were higher among those with any food insecurity, while the prevalence of alcohol consumption was lower in this group. Furthermore, those with any food insecurity had fewer years of education. The prevalence of food insecurity, suicidal ideation, and suicide attempts

by country are shown in **Table S1** of the Appendix. The prevalence of moderate food insecurity ranged from 0.9% in China to 23.5% in Ghana, while that of severe food insecurity ranged from 0.3% in China to 21.5% in South Africa. The range in prevalence for suicidal ideation and suicide attempts were 0.7% (China) to 7.6% (Mexico), and 0.3% (China) to 4.6% (Mexico), respectively. The prevalence of both suicidal ideation and suicide attempts increased with increasing severity of food insecurity (**Figure 1**). For example, the prevalence of suicide attempts was only 0.4% among those without food insecurity but this increased to 2.7% among those with severe food insecurity.

The association between food insecurity and suicidal ideation and suicide attempts estimated by multivariable logistic regression is shown in **Table II**. Compared to no food insecurity, severe food insecurity was associated with a significant 2.78 (95%CI=1.73-4.45) times higher odds for suicidal ideation. Furthermore, compared to no food insecurity, moderate and severe food insecurity were associated with 2.59 (95%CI=1.35-4.97) and 5.15 (95%CI=2.52-10.53) times higher odds for suicide attempts, respectively. The corresponding figures for isolated suicidal ideation were 1.22 (95%CI=0.77-1.93) for moderate food insecurity, and 2.32 (95%CI=1.36-3.95) for severe food insecurity (data shown only in text). The country-wise association between any food insecurity and suicidal ideation estimated by multivariable logistic regression is shown in **Figure 2**, and the corresponding association for suicide attempts is shown in **Figure 3**. The level of between-country heterogeneity based on the  $I^2$  was 0.0% (95%CI=0%-75%) and 17.4% (95%CI=0%-62%) for suicidal ideation and suicide attempts, respectively.

## DISCUSSION

### *Main findings*

In this large sample of older adults from six LMICs (China, Ghana, India, Mexico, Russia, South Africa), it was found that when compared to no food insecurity, severe food insecurity was associated with 2.78 times higher odds for suicidal ideation, while moderate and severe food insecurity were associated with 2.59 and 5.1 times higher odds for suicide attempts, respectively.

### *Interpretation of the findings*

The present findings are in line with previous literature that has found associations between food insecurity and suicidal thoughts or behaviors among adults in high-income countries and adolescents in LMICs (Davison KM et al., 2015; Bergmans RS et al., 2020). Our findings also address a knowledge gap in the previous literature by demonstrating that an association exists in older adults residing in LMICs. This is of importance as older adults are at the greatest risk of suicide and the greatest proportion of suicides occur in LMICs, while food insecurity is also more common in this setting (Shah, A et al., 2016; World Health Organisation, 2019).

There are multiple plausible pathways that could explain the association between food insecurity and suicidal thoughts and behaviors. Firstly, as previously mentioned, poor nutrition, stress, and shame in food insecurity may lead to increased risk for mental health problems (Jones AD., 2019), and mental health problems are an important risk factor for suicidal behaviors (Nepon, J. et al., 2010; Miller, M., & Hemenway, D., 2008). In terms of poor nutrition, food scarcity influences people to shift to food that is more affordable but lower in nutrients (e.g., high fat, high carbohydrate, low vitamins) or have low caloric intake

(Smith L et al., 2021<sup>a</sup>; Pilgrim A et al., 2012). Previous studies have shown that fast food consumption is positively associated with suicide attempts (Jacob, L et al., 2020). This association may be driven by fast food consumption leading to inflammation, insulin resistance, and increasing vulnerability to traumatic stress via alterations in brain structure and function (Jacob, L et al., 2020). Furthermore, low caloric intake has been associated with impaired hypothalamic-pituitary-adrenal (HPA) axis reactivity to stress (Macht, M., 1996), and this in turn may lead to an increased risk for suicidality (Berardelli I et al., 2020). Next, food insecurity may potentially cause frailty that in turn is associated with suicidal thoughts (Pérez-Zepeda MU et al., 2016; Bickford D et al., 2021) via depression severity and comorbidities (Bickford D et al., 2021). Finally, food insecurity has been associated with loneliness and a lack of social support both of which may partially contribute to a higher risk of suicidal behaviors (Burris M et al., 2021).

### ***Public health implications***

The results of our study indicate that addressing food insecurity in LMICs may lead to reduction in suicidal thoughts and behaviors. Addressing food insecurity in such economic settings requires strong governmental, societal and international community efforts. It is possible to draw on learnings from high-income countries to begin to address food insecurity in LMICs. For example, in many high-income countries, initiatives exist such as “Meals on Wheels” which have been identified as promising in combating undernutrition among older adults (Goeminne, PC et al., 2012). Moreover, such schemes can be utilized to tackle isolation (Meals on Wheels America., N.d) and thus may be able to address other risk factors relating to suicidal behavior among older adults. However, whether such schemes would be successful in LMICs remains untested.

### ***Strengths and limitations***

Strengths of the study include the use of a large sample of older adults from six LMICs. However, findings should be interpreted in light of the study limitations. First, the study is cross-sectional, and therefore, it is not known whether the relationship between food insecurity and suicidal ideation or suicide attempts is bidirectional. For example, a suicide attempt may result in serious injury that in turn may lead to unemployment and consequently food insecurity, particularly in LMICs. Second, the majority of the data analyzed relied on self-report, which could be influenced by reporting bias. It is also possible that cultural differences may have resulted in different interpretations at the survey questions. Third, the measure of suicidal ideation used was related to wish to die, which has been differentiated from active suicidal ideation. However, the presence of wishes to die has been reported as clinically important as the presence of active suicidal ideation (Cabello M et al., 2020). Fourth, the study may have underestimated those with suicidal ideation and suicide attempts, as suicidal ideation and suicide attempts were only assessed among those who had depressive symptoms (sadness, loss of interest or low energy). However, depressive symptoms are common in people with suicidal behavior (Wang YH et al., 2017). Finally, the estimates on suicidality obtained for each country had wide confidence intervals and often lacked precision. Future studies with larger sample size are necessary to obtain country-wise estimates with more precision.

### ***Conclusions***

Food insecurity is positively associated with suicidal ideation and suicide attempts among older adults in LMICs, with odds for suicide attempts being more than five times higher in those with severe insecurity (vs. no food insecurity). Future interventional or longitudinal

studies are warranted to examine whether addressing food insecurity in LMICs among older adults may reduce levels of suicidal ideation and suicide attempts.

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## COMPETING INTERESTS

The authors have no competing interested to declare.

## References

1. Berardelli, I., Serafini, G., Cortese, N., Fiaschè, F., O'Connor, R. C., & Pompili, M. (2020). The Involvement of Hypothalamus-Pituitary-Adrenal (HPA) Axis in Suicide Risk. *Brain sciences*, 10(9), 653. <https://doi.org/10.3390/brainsci10090653>
2. Bergmans, R. S., Jannausch, M., & Ilgen, M. A. (2020). Prevalence of suicide ideation, planning and attempts among Supplemental Nutrition Assistance Program participants in the United States. *Journal of affective disorders*, 277, 99–103. <https://doi.org/10.1016/j.jad.2020.07.129>
3. Bickel, G., Nord, M., Price, C., Hamilton, W., & Cook, J., (2000) Guide to Measuring Household Food Security, Revised 2000. U.S. Department of Agriculture, Food and Nutrition Service, Alexandria VA. Accessed at: <https://alliancetoendhunger.org/wp-content/uploads/2018/03/USDA-guide-to-measuring-food-security.pdf>
4. Bickford, D., Morin, R. T., Woodworth, C., Verduzco, E., Khan, M., Burns, E., Nelson, J. C., & Mackin, R. S. (2021). The relationship of frailty and disability with suicidal ideation in late life depression. *Aging & mental health*, 25(3), 439–444. <https://doi.org/10.1080/13607863.2019.1698514>
5. Bickford, D., Morin, R. T., Woodworth, C., Verduzco, E., Khan, M., Burns, E., Nelson, J. C., & Mackin, R. S. (2021). The relationship of frailty and disability with suicidal ideation in late life depression. *Aging & mental health*, 25(3), 439–444. <https://doi.org/10.1080/13607863.2019.1698514>
6. Bickford, D., Morin, RT., Woodworth, C., Verduzco, E., Khan, M., Burns, E., Nelson, CJ., & Scott, MR. (2021) The relationship of frailty and disability with suicidal ideation in late life depression, *Aging & Mental Health*, 25 (3) 439-444. <https://doi.org/10.1080/13607863.2019.1698514>

7. Borges G, Bagge CL, Cherpitel CJ, Conner KR, Orozco R, Rossow I (2017) A meta-analysis of acute use of alcohol and the risk of suicide attempt. *Psychol Med* 47, 949-957.
8. Burris, M., Kihlstrom, L., Serrano Arce, K., Prendergast, K., Dobbins, J., McGrath, E., Renda, A., Shannon, E., Cordier, T., Song, Y., & Himmelgreen, D (2021) Food Insecurity, Loneliness, and Social Support among Older Adults, *Journal of Hunger & Environmental Nutrition*, 16 (1) 29-44. <http://doi.org/10.1080/19320248.2019.1595253>
9. Cabello M, Miret M, Ayuso-Mateos JL, Caballero FF, Chatterji S, Tobiasz-Adamczyk B, Haro JM, Koskinen S, Leonardi M, Borges G (2020) Cross-national prevalence and factors associated with suicide ideation and attempts in older and young-and-middle age people. *Aging Ment Health* 24, 1533-1542.
10. Callahan, C. M., Hendrie, H. C., Nienaber, N. A., & Tierney, W. M. (1996). Suicidal ideation among older primary care patients. *Journal of the American Geriatrics Society*, 44(10), 1205–1209. <https://doi.org/10.1111/j.1532-5415.1996.tb01370.x>
11. Chiu, H. F., Dai, J., Xiang, Y. T., Chan, S. S., Leung, T., Yu, X., Hou, Z. J., Ungvari, G. S., & Caine, E. D. (2012). Suicidal thoughts and behaviors in older adults in rural China: a preliminary study. *International journal of geriatric psychiatry*, 27(11), 1124–1130. <https://doi.org/10.1002/gps.2831>
12. Conejero, I., Olié, E., Courtet, P., & Calati, R. (2018). Suicide in older adults: current perspectives. *Clinical interventions in aging*, 13, 691–699. <https://doi.org/10.2147/CIA.S130670>
13. Davison, K. M., Marshall-Fabien, G. L., & Tecson, A. (2015). Association of moderate and severe food insecurity with suicidal ideation in adults: national survey data from three Canadian provinces. *Social psychiatry and psychiatric epidemiology*, 50(6), 963–972. <https://doi.org/10.1007/s00127-015-1018-1>
14. Devylder, JE., Lukens, EP., Link, BG., Liberman JA. (2015) Suicidal ideation and suicide attempts among adults with psychotic experiences: data from the collaborative psychiatric epidemiology surveys. *JAMA psychiatry (Chicago, Ill)*, 72, 219-25
15. De Leo, D., Padoani, W., Lonnqvist, J., Kerkhof, A. J., Bille-Brahe, U., Michel, K., Salander-Renberg, E., Schmidtke, A., Wasserman, D., Caon, F., & Scocco, P. (2002). Repetition of suicidal behaviour in elderly Europeans: a prospective longitudinal study. *Journal of affective disorders*, 72(3), 291–295. [https://doi.org/10.1016/s0165-0327\(01\)00454-2](https://doi.org/10.1016/s0165-0327(01)00454-2)
16. Ghose B, Wang R, Tang S, Yaya S (2019) Engagement in physical activity, suicidal thoughts and suicide attempts among older people in five developing countries. *PeerJ* 7, e7108.
17. Goeminne, P. C., De Wit, E. H., Burtin, C., & Valcke, Y. (2012). Higher food intake and appreciation with a new food delivery system in a Belgian hospital. Meals on Wheels, a bedside meal approach: a prospective cohort trial. *Appetite*, 59(1), 108–116. <https://doi.org/10.1016/j.appet.2012.04.008>
18. Harmer, B., Lee, S., Duong, T., & Saadabadi, A. (2021). Suicidal Ideation. In StatPearls. StatPearls Publishing.
19. Harmer, B., Lee, S., Duong, TvH., et al. Suicidal Ideation. [Updated 2021 Apr 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Accessed at: <https://www.ncbi.nlm.nih.gov/books/NBK565877/><sup>a</sup>
20. Higgins, J. P., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in medicine*, 21(11), 1539–1558. <https://doi.org/10.1002/sim.1186>
21. Jacob, L., Stubbs, B., Firth, J., Smith, L., Haro, J. M., & Koyanagi, A. (2020). Fast food consumption and suicide attempts among adolescents aged 12-15 years from 32 countries. *Journal of affective disorders*, 266, 63–70. <https://doi.org/10.1016/j.jad.2020.01.130>
22. Jones, A. D., (2017). Food Insecurity and Mental Health Status: A Global Analysis of 149 Countries. *American Journal of Preventive Medicine*, 53 (2), 264-273. <https://doi.org/10.1016/j.amepre.2017.04.008>

23. Jordans, M., Rathod, S., Fekadu, A., Medhin, G., Kigozi, F., Kohrt, B., Luitel, N., Petersen, I., Shidhaye, R., Ssebunnya, J., Patel, V., Lund, C., (2018). Suicidal ideation and behaviour among community and health care seeking populations in five low- and middle-income countries: a cross-sectional study. *Epidemiol Psychiatr Sci.* 27(4): 393–402.  
<https://doi.org/10.1017/S2045796017000038>
24. Kowal P, Chatterji S, Naidoo N, Biritwum R, Fan W, Lopez Ridaura R, Maximova T, Arokiasamy P, Phaswana-Mafuya N, Williams S, Snodgrass JJ, Minicuci N, D'Este C, Peltzer K, Boerma JT (2012) Data resource profile: the World Health Organization Study on global AGEing and adult health (SAGE). *Int J Epidemiol* 41, 1639-1649.
25. Koyanagi, A., Stubbs, B., Oh, H., Veronese, N., Smith, L., Haro, J. M., & Vancampfort, D. (2019). Food insecurity (hunger) and suicide attempts among 179,771 adolescents attending school from 9 high-income, 31 middle-income, and 4 low-income countries: A cross-sectional study. *Journal of affective disorders*, 248, 91–98.  
<https://doi.org/10.1016/j.jad.2019.01.033>
26. Liao, S. J., Wu, B. J., Liu, T. T., Chou, C. P., & Rong, J. R. (2018). Prevalence and characteristics of suicidal ideation among 2199 elderly inpatients with surgical or medical conditions in Taiwan. *BMC psychiatry*, 18(1), 397. <https://doi.org/10.1186/s12888-018-1981-7>
27. Macht, M., (1996) Effects of High- and Low-Energy Meals on Hunger, Physiological Processes and Reactions to Emotional Stress. *Appetite*, 26 (1), 71-88
28. Meals on Wheels America (N.d) COMBATING SENIOR SOCIAL ISOLATION AND LONELINESS. Accessed at: [https://www.mealsonwheelsamerica.org/docs/default-source/advocacy/meals-on-wheels-america-social-isolation-and-loneliness-overview.pdf?sfvrsn=b5f4b43b\\_2](https://www.mealsonwheelsamerica.org/docs/default-source/advocacy/meals-on-wheels-america-social-isolation-and-loneliness-overview.pdf?sfvrsn=b5f4b43b_2)
29. Miller, M., & Hemenway, D., (2008). Guns and Suicide in the United States. *N Engl J Med.* 359: 989-991. <http://doi.org.10.1056/NEJMp0805923>
30. Montgomery J, Lu J, Ratliff S, Mezuk B (2017) Food Insecurity and Depression Among Adults With Diabetes: Results From the National Health and Nutrition Examination Survey (NHANES). *Diabetes Educ* 43, 260-271.
31. Murat, A., Cicek, H., Bulent B. (2019). Description of suicide ideation among older adults and a psychological profile: a cross-sectional study in Turkey. *Ciênc. Saúde Colet*, 24(5): 1865-1874.
32. Naghavi, M., (2019) Global, regional, and national burden of suicide mortality 1990 to 2016: systematic analysis for the Global Burden of Disease Study 2016. *BMJ*, 364 :l94  
<http://doi.org/10.1136/bmj.l94>
33. Nepon, J., Belik, S. L., Bolton, J., & Sareen, J. (2010). The relationship between anxiety disorders and suicide attempts: findings from the National Epidemiologic Survey on Alcohol and Related Conditions. *Depression and anxiety*, 27(9), 791–798.  
<https://doi.org/10.1002/da.20674>
34. O'Connor, E., Gaynes, B., Burda, BU., et al. (2013) Screening for Suicide Risk in Primary Care: A Systematic Evidence Review for the U.S. Preventive Services Task Force [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); (Evidence Syntheses, No. 103.) Table 1, Definitions of Suicide-Related Terms. Accessed at: <https://www.ncbi.nlm.nih.gov/books/NBK137739/table/ch1.t1/>
35. O'Riley, A. A., Van Orden, K. A., He, H., Richardson, T. M., Podgorski, C., & Conwell, Y. (2014). Suicide and death ideation in older adults obtaining aging services. *The American journal of geriatric psychiatry : official journal of the American Association for Geriatric Psychiatry*, 22(6), 614–622. <https://doi.org/10.1016/j.jagp.2012.12.004>
36. Pérez-Zepeda, M. U., Castrejón-Pérez, R. C., Wynne-Bannister, E., & García-Peña, C. (2016). Frailty and food insecurity in older adults. *Public health nutrition*, 19(15), 2844–2849.  
<https://doi.org/10.1017/S1368980016000987>



37. Pilgrim, A., Barker, M., Jackson, A., Ntani, G., Crozier, S., Inskip, H., Godfrey, K., Cooper, C., Robinson, S., (2012) Does living in a food insecure household impact on the diets and body composition of young children? Findings from the Southampton Women's SurveyJ Epidemiol Community Health. 66:e6.
38. Pirrie, M., Harrison, L., Angeles, R. Marzanek, F. Zeismann A & Agarwal G. (2020) Poverty and food insecurity of older adults living in social housing in Ontario: a cross-sectional study. BMC Public Health 20, 1320 <https://doi.org/10.1186/s12889-020-09437-3>
39. Reitzel LR, Chinamuthevi S, Daundasekara SS, Hernandez DC, Chen TA, Harkara Y, Obasi EM, Kendzor DE, Businelle MS (2020) Association of Problematic Alcohol Use and Food Insecurity among Homeless Men and Women. Int J Environ Res Public Health 17.
40. Shah, A., Bhat, R., Zarate-Escudero, S., DeLeo D., & Erlangsen, A. (2016) Suicide rates in five-year age-bands after the age of 60 years: the international landscape, Aging & Mental Health, 20(2), 131-138, <http://doi.org/10.1080/13607863.2015.1055552>
41. Shah, A., Bhat, R., Zarate-Escudero, S., DeLeo, D., & Erlangsen A. (2016) Suicide rates in five-year age-bands after the age of 60 years: the international landscape, Aging & Mental Health, 20 (2) 131-138. <http://doi.org/10.1080/13607863.2015.1055552>
42. Shah, A., Hoxey, K., & Mayadunne, V. (2000). Suicidal ideation in acutely medically ill elderly inpatients: prevalence, correlates and longitudinal stability. International journal of geriatric psychiatry, 15(2), 162–169. [https://doi.org/10.1002/\(sici\)1099-1166\(200002\)15:2<162::aid-gps94>3.0.co;2-t](https://doi.org/10.1002/(sici)1099-1166(200002)15:2<162::aid-gps94>3.0.co;2-t)
43. Shayo, F.K., Lawala, P.S. (2019) Does food insecurity link to suicidal behaviors among in-school adolescents? Findings from the low-income country of sub-Saharan Africa. BMC Psychiatry 19, 227. <https://doi.org/10.1186/s12888-019-2212-6>
44. Sirey, J. A., Bruce, M. L., Carpenter, M., Booker, D., Reid, M. C., Newell, K. A., & Alexopoulos, G. S. (2008). Depressive symptoms and suicidal ideation among older adults receiving home delivered meals. International journal of geriatric psychiatry, 23(12), 1306–1311. <https://doi.org/10.1002/gps.2070>
45. Smith L, Il Shin J, McDermott D, Jacob L, Barnett Y, López-Sánchez GF, Veronese N, Yang L, Soysal P, Oh H, Grabovac I, Koyanagi A (2021) Association between food insecurity and depression among older adults from low- and middle-income countries. Depress Anxiety 38, 439-446.
46. Smith L, Shin JI, Barnett Y, Allen PM, Lindsay R, Pizzol D, Jacob L, Oh H, Yang L, Tully MA, Veronese N, Koyanagi A. (2021) Association of objective visual impairment with suicidal ideation and suicide attempts among adults aged ≥50 years in low/middle-income countries. British Journal of Ophthalmology. <https://doi.org/10.1136/bjophthalmol-2021-318864>
47. Smith L, Shin JI, Barnett Y, Allen PM, Lindsay R, Pizzol D, Jacob L, Oh H, Yang L, Tully MA, Veronese N, Koyanagi A (2021) Association of objective visual impairment with suicidal ideation and suicide attempts among adults aged ≥50 years in low/middle-income countries. Br J Ophthalmol.
48. Smith, L., Barnett, Y., López-Sánchez, G., Shin, J., Jacob, L., Butler, L., Cao, C., Yang, L., Schuch F, Tully M & Koyanagi, A. (2021). Food insecurity (hunger) and fast-food consumption among 180 164 adolescents aged 12–15 years from sixty-eight countries. British Journal of Nutrition, 1-8. doi:10.1017/S0007114521001173<sup>a</sup>
49. Smith, MD., & Meade, B., Who Are the World's Food Insecure? Identifying the Risk Factors of Food Insecurity Around the World. (2019) Accessed at: <https://www.ers.usda.gov/amber-waves/2019/june/who-are-the-world-s-food-insecure-identifying-the-risk-factors-of-food-insecurity-around-the-world/>
50. Wang, YH., Shi, ZT., & Luo, QY. (2017). Association of depressive symptoms and suicidal ideation among university students in China: A systematic review and meta-analysis. Medicine, 96(13), e6476. <https://doi.org/10.1097/MD.0000000000006476>

51. World Health Organisation, 2021. Suicide. Accessed at: <https://www.who.int/news-room/fact-sheets/detail/suicide>

## **Tables and Figures**

**Table I** Sample characteristics (overall and by any food insecurity)

Characteristic		Overall	Any food insecurity		P-value <sup>a</sup>
			No	Yes	
Suicidal ideation	No	96.6	97.3	91.5	<0.001
	Yes	3.4	2.7	8.5	
Suicide attempts	No	99.4	99.6	97.8	<0.001
	Yes	0.6	0.4	2.2	
Sex	Female	52.1	51.3	57.4	0.003
	Male	47.9	48.7	42.6	
Age (years)	Mean (SD)	62.4 (16.0)	62.4 (15.6)	61.9 (18.8)	0.250
Wealth	Poorest	17.1	14.6	35.6	<0.001
	Poorer	19	17.9	26.5	
	Middle	19.5	19.9	17.0	
	Richer	21.3	22.3	14.3	
	Richest	23.1	25.3	6.6	
Education (years)	Mean (SD)	6.0 (8.9)	6.2 (8.6)	4.2 (10.1)	<0.001
Unemployed	No	42.7	42.9	41.3	0.525
	Yes	57.3	57.1	58.7	
Smoking	Never	58.6	59.5	51.0	<0.001
	Current	34.9	33.8	42.9	
	Quit	6.6	6.6	6.1	
Alcohol consumption	No	81.3	80.9	84.1	0.023
	Yes	18.7	19.1	15.9	
Physical activity	High	49.1	48.0	57.4	<0.001
	Moderate	22.8	23.7	15.5	
	Low	28.1	28.2	27.0	
Self-rated health	Not poor	78.2	79.4	69.5	<0.001
	Poor	21.8	20.6	30.5	

Abbreviation: SD Standard deviation.

Data are % unless otherwise stated.

<sup>a</sup> P-value was based on Chi-squared tests and Students' *t*-tests for categorical and continuous variables, respectively.

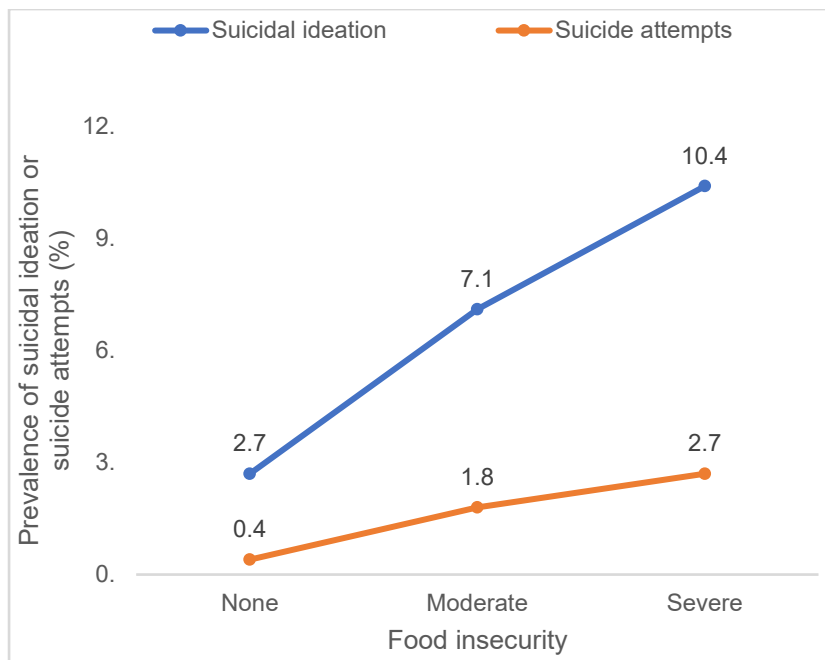
**Table II** Association between food insecurity (or covariates) and suicidal ideation/suicide attempts (outcomes) estimated by multivariable logistic regression

Characteristic		Suicidal ideation		Suicide attempts	
		OR	95%CI	OR	95%CI
Food insecurity	None	1.00		1.00	
	Moderate	1.35	[0.90,2.02]	2.59**	[1.35,4.97]
	Severe	2.78***	[1.73,4.45]	5.15***	[2.52,10.53]
Sex	Female	1.00		1.00	
	Male	0.43***	[0.31,0.62]	0.33**	[0.15,0.76]
Age (years)		1.00	[0.98,1.02]	1.02	[0.99,1.06]
Wealth	Poorest	1.00		1.00	
	Poorer	1.50	[0.95,2.37]	1.45	[0.69,3.05]
	Middle	1.22	[0.80,1.88]	1.58	[0.78,3.20]
	Richer	0.93	[0.63,1.39]	1.62	[0.71,3.70]
	Richest	0.88	[0.60,1.29]	1.26	[0.59,2.68]
Education (years)		1.03	[0.99,1.07]	1.00	[0.93,1.07]
Unemployed	No	1.00		1.00	
	Yes	1.24	[0.93,1.67]	1.23	[0.70,2.14]
Smoking	Never	1.00		1.00	
	Current	1.15	[0.85,1.56]	1.52	[0.76,3.04]
	Quit	2.10**	[1.29,3.42]	3.47**	[1.64,7.36]
Alcohol consumption	No	1.00		1.00	
	Yes	1.12	[0.71,1.77]	2.38*	[1.11,5.14]
Physical activity	High	1.00		1.00	
	Moderate	1.15	[0.85,1.54]	0.93	[0.51,1.69]
	Low	0.93	[0.66,1.31]	1.01	[0.63,1.63]
Self-rated health	Not poor	1.00		1.00	
	Poor	3.38***	[1.90,6.01]	3.14***	[2.00,4.93]

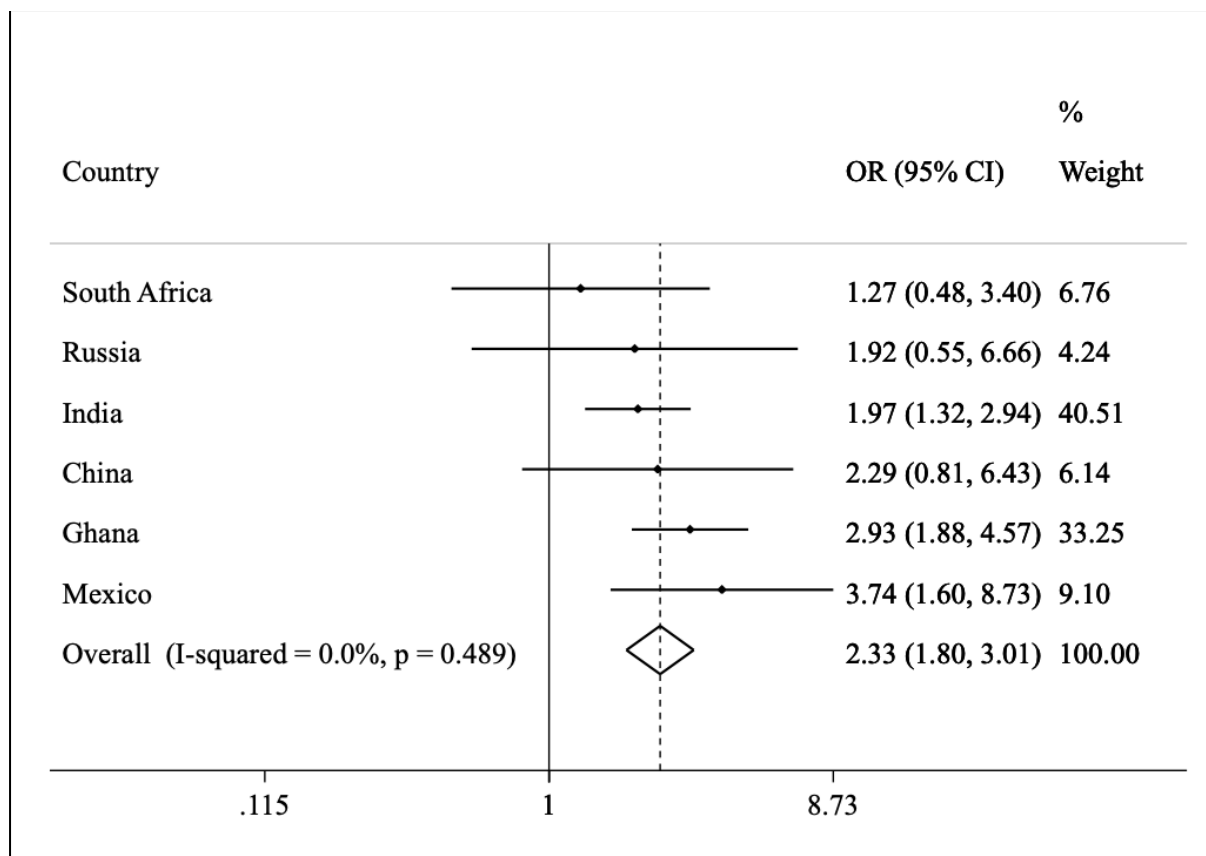
Abbreviation: OR Odds ratio; CI Confidence interval

Models are mutually adjusted for all covariates in the Table and country.

\* p<0.05, \*\* p<0.01, \*\*\* p<0.001



**Figure 1** Prevalence of suicidal ideation and suicide attempts by level of food insecurity

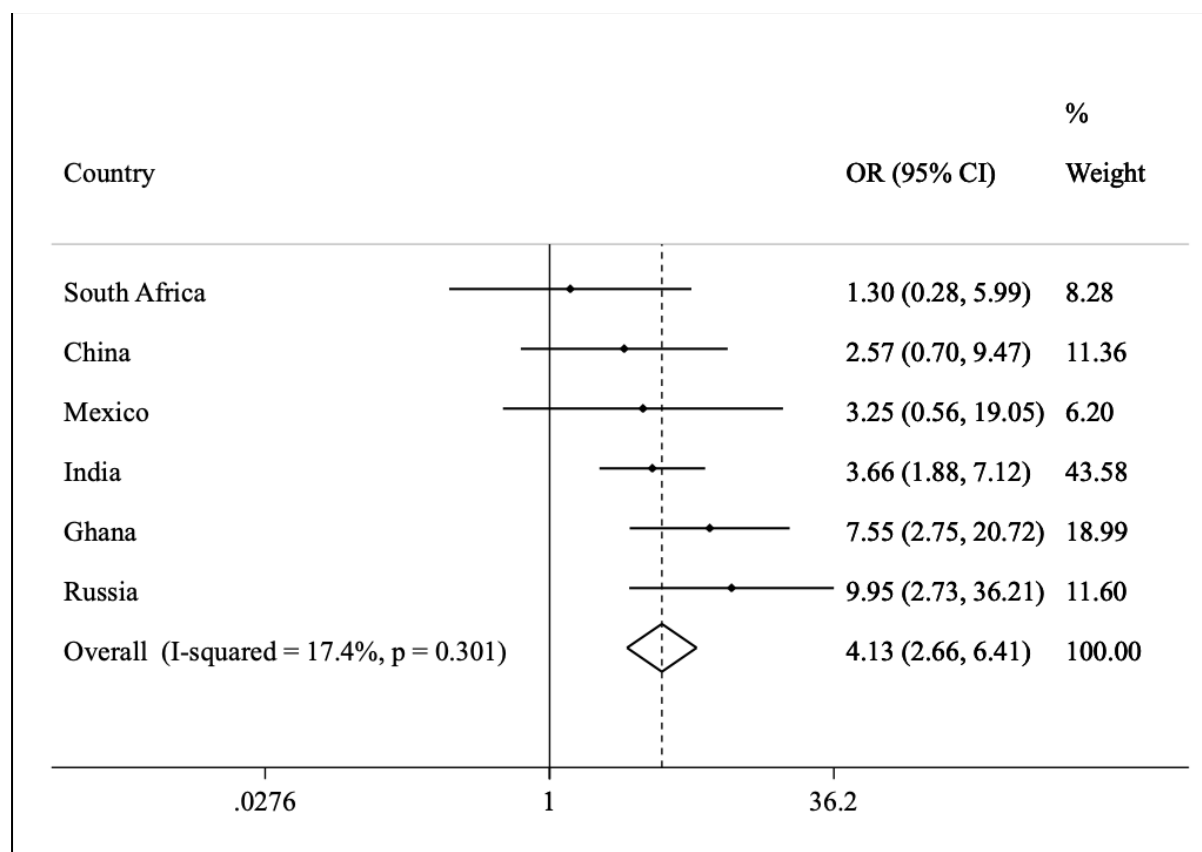


**Figure 2** Country-wise association between any food insecurity and suicidal ideation estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, wealth, education, unemployment, physical activity, alcohol consumption, smoking, and poor self-rated health.

Overall estimate is based on meta-analysis with fixed effects.



**Figure 3** Country-wise association between any food insecurity and suicide attempts estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, wealth, education, unemployment, physical activity, alcohol consumption, smoking, and poor self-rated health.

Overall estimate is based on meta-analysis with fixed effects.