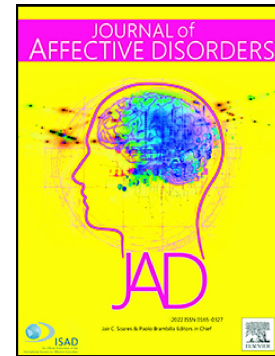


The global burden of suicidal behavior among people experiencing food insecurity: A systematic review and meta-analysis

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The Global Burden of Suicidal Behavior Among People Experiencing Food Insecurity: A Systematic Review and Meta-analysis

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Abstract

Background

Food insecurity has become a growing burden within a global context where climate change, catastrophes, wars, and insurgencies are increasingly prevalent. Several studies have reported an association between suicidal behaviors (i.e., suicide ideation, plans, and attempts) and food insecurity. This meta-analytic review for the first time, synthesized the available literature to determine the pooled prevalence of suicidal behaviors among individuals experiencing food insecurity, and examined the strength of their association.

Methods

Databases (*Ovid, PubMed, Web of Science, and CINAHL*) were searched from inception to July 2022 using the appropriate search term. Eligible studies reporting the number/prevalence of suicidal behaviors among individuals experiencing food insecurity or the association between food insecurity and suicidal behaviors were included. The pooled prevalence of suicidal behaviors was determined using the random-effects model. The review was registered with PROSPERO (CRD42022352858).

Results

A total of 47 studies comprising 75,346 individuals having experienced food insecurity were included. The pooled prevalence was 22.3% for suicide ideation (95% CI: 14.7-29.9; $I^2=99.6\%$, $p<0.001$, $k=18$), 18.1% for suicide plans (95% CI: 7.0-29.1; $I^2=99.6\%$, $p<0.001$, $k=4$), 17.2% for suicide attempts (95% CI: 9.6-24.8; $I^2=99.9\%$, $p<0.001$, $k=12$), and 4.6% for unspecified suicidal behavior (95% CI: 2.8-6.4; $I^2=85.5\%$, $p<0.001$, $k=5$). There was a positive relationship between experiencing food insecurity and (i) suicide ideation

(aOR=1.049 [95% CI: 1.046-1.052; $I^2=99.6\%$, $p<0.001$, $k=31$]), (ii) suicide plans (aOR=1.480 [95% CI: 1.465-1.496; $I^2=99.1\%$, $p<0.001$, $k=5$]), and (iii) unspecified suicide behaviors (aOR=1.133 [95% CI: 1.052-1.219; $I^2=53.0\%$, $p=0.047$, $k=6$]). However, a negative relationship was observed between experiencing food insecurity and suicide attempts (aOR=0.622 [95% CI: 0.617-0.627; $I^2 = 98.8\%$, $p<0.001$, $k=15$]). The continent and the countries income status where the study was conducted were the common cause of heterogeneity of the differences in the odds of the relationships between experiencing food insecurity and suicidal behaviors - with North America and high-income countries (HICs) having higher odds. For suicide attempts, all non HICs had a negative relationship with food insecurity.

Limitations

There was significant heterogeneity among the included studies.

Conclusion

There is a high prevalence of suicidal behaviors among individuals experiencing food insecurity. Initiatives to reduce food insecurity would likely be beneficial for mental wellbeing and to mitigate the risk of suicidal behaviors among population experiencing food insecurity.

The paradoxical finding of suicide attempts having a negative relationship with food insecurity warrants further research.

Keywords: Food insecurity; hunger; suicide behavior; suicide ideation; suicide plan; suicide attempt; meta-analysis

Introduction

Food insecurity is defined as the lack of access to safe, healthy, and nutritious food for

regular growth and development due to financial hindrances, lack of resources to obtain food, or unavailability of food (Food and Agriculture Organization of the United Nations, 2022). It is considered a global public health concern, affecting about 800 million individuals worldwide (Food and Agriculture Organization of the United Nations, 2022). Recent global estimates suggested an increasing trend of undernourishment prevalence (i.e., 9.8% in 2021, 9.3% in 2020, and 8.4% in 2019) (Food and Agriculture Organization of the United Nations, 2022). Given this situation, the World Food Program claimed that approximately 50 million individuals from 45 countries in the world teetering on the edge of famine, starvation, and massive migration due to the current shortage in food production and supply (World Food Program, 2022).

Drivers to food insecurity are complex and stem from psychosocial, political, economic, and cultural factors (Brady et al., 2021). Frameworks have been used to describe the complex relationship between the various drivers and food insecurity such as the social exclusion theoretical framework that describes how unequal access to rights, resources, and capabilities results in political, economic, social, and cultural vulnerability, leading to food insecurity (Brady et al., 2021). Such a framework provides reasons as to why the countries with low income status, marginalized populations, older individuals, and/or war affected areas (among others) are affected by higher levels of food insecurity (Brady et al., 2021; Jung et al., 2017).

Experiencing food insecurity has substantial negative impacts on individuals' physical, psychological, and socio-economic well-being (Pourmotabbed et al., 2020a). For example, experiencing food insecurity is associated with mood disorders, depressive symptoms, anxiety, stress, decreased quality of life, and suicidal behaviors (Davison et al., 2015;

McAuliffe et al., 2021; Pourmotabbed et al., 2020a). Suicidal behavior among individuals experiencing food insecurity may be due to mental health symptoms, sleep problems, and continuous failure to cope with the inability to provide food for themselves or their family (Davison et al., 2015; McAuliffe et al., 2021; Nagata et al., 2019; Pourmotabbed et al., 2020a). Many individuals with suicidal behavior related to experiencing food insecurity may end up dying by suicide. Both suicide and experiencing food insecurity have been on the rise following the recent changes in global events such as increased levels of poverty, the Ukraine-Russia war, the coronavirus-2019 (COVID-19) pandemic, reduction in global soil fertilizers production, reduction in global grain production, and climate change (Curtin et al., 2021; World Food Program, 2022). As a consequence of the continuous failure to rectify the growing food insecurity problem, an increasing number of individuals might either migrate to look for food or resort to dying by suicide.

A number of theories and hypotheses can be applied to describe the association between food insecurity and suicidal behaviors, including stress theory, social support theory, and hopelessness theory. Stress theory suggests that food insecurity causes chronic stress and psychological distress, which can impair the cognitive and emotional functioning of individuals/families and increase their vulnerability to suicidal behaviors (Intagliata, 2023). Food insecurity can also trigger or exacerbate other stressors, such as financial difficulties, social isolation, stigma, discrimination, or violence, which can further increase the risk for involving in suicidal behaviors (Shayo and Lawala, 2019). Social support theory is a theory derived from the reduction of crime and delinquency activities through social support (Kort-Butler, 2017). In regards to food insecurity and suicidal behaviors, food insecurity can undermine the availability and quality of social support for individuals and families.

Through these individuals feeling and struggle with shame, isolated, and stigmatised that reduce their willingness to seek and receive social support (Burris et al., 2021). These can eventually reduce their coping resources and resilience and contribute to suicidal behaviors (Graham and Ciciurkaite, 2022). The hopelessness theory, a theory commonly used to describe the relationship between depression (a major risk factor for suicidal behaviors) and food insecurity (Liu et al., 2015). This theory posits that food insecurity can also create a sense of helplessness, powerlessness, or fatalism, which can make individuals feel that they have no control over their lives or that there is no solution to their problems, which can increase the probability of suicide or experiencing suicidal behaviors (Stebbleton et al., 2020). Suicidal behaviors are a spectrum of behaviors ranging from suicide ideation/thoughts, suicide plans, suicide attempts, and then dying by suicide. Suicidal behaviors can be caused by a complex mix of social, emotional, psychological, biological, environmental, and personal factors, and experiencing food insecurity can be one of the contributory factors. However, several studies have reported varying prevalences of suicidal behaviors among individuals experiencing food insecurity (Abrahams et al., 2018; Alaimo et al., 2002; Altangerel et al., 2014; Chung et al., 2016; Davison et al., 2015; Dema et al., 2019; Dumith et al., 2020; Ju et al., 2016; McAuliffe et al., 2021; Mwambene et al., 2013; Nagata et al., 2019; Oh et al., 2022; Oppong Asante et al., 2017; Pryor et al., 2016; Romo et al., 2016; Shayo and Lawala, 2019; Skeen et al., 2014; Smith et al., 2022; Yang, 2015). For example, a study among pregnant women in South Africa from a low socio-economic setting (n=376) reported that 40.4% of individuals experiencing food insecurity had suicide ideation, and 66.7% expressed suicidal behaviors (Abrahams et al., 2018). Another study among Mongolian high school students (n=5191) reported that the prevalence of suicide ideation,

suicide plans, and suicide attempts was 25%, 16.7%, and 12.5% respectively among hungry students (Altangerel et al., 2014). Similarly, Korean adults (n=5862) reported that the prevalence of suicide ideation was 11.5% among food-insecure households without hunger (n=381), whereas the rate was 27.9% among food-insecure households with hunger (n=68) (Chung et al., 2016). A 13.2% prevalence of experiencing suicidal thoughts/feelings was reported among Canadian adults (n=3000) who worried about food in the previous two weeks (McAuliffe et al., 2021).

In addition, various strengths of association between experiencing food insecurity and suicidal behaviors have also been reported. For example, a study among Canadian adults reported that participants with food worry had 1.87-times higher rates of suicidal thoughts compared to those who were not (McAuliffe et al., 2021). Another study among low-and middle-income countries adults aged ≥ 50 years (n=34,129) demonstrated that experiencing severe food insecurity increased the odds for suicide ideation (2.87), and suicide attempts (5.15), whereas participants experiencing moderate food insecurity had 2.59-times higher rate of suicide ideation than those who were not (Smith et al., 2022). Also, a Tanzanian Global School-based Student Health Survey (GSHS) 2014 comprising 3793 adolescents reported that adolescents experiencing food insecurity were significantly more likely to have thought about suicide (1.8 times) and attempt suicide (2.4 times) (Shayo and Lawala, 2019). Similarly, the School-based Student Health Survey in Bhutan in 2016 comprising school-going adolescents reported that participants who had always experienced food insecurity were twice the risk of having suicide attempts, whereas the rate was 1.3-times for those who had suicide ideation compared to those who did not (Dema et al., 2019). Despite many studies showing a demonstrable relationship between experiencing food insecurity and

suicide behaviors, contradictory findings have also been reported. For example, while some studies have reported significant positive relationship (McAuliffe et al., 2021; Nagata et al., 2019; Njunju et al., 2017; Oh et al., 2022; Oppong Asante et al., 2017; Pandey et al., 2019; Pryor et al., 2016; Shayo and Lawala, 2019), negative relationship (Altangerel et al., 2014) or no relationship between experiencing food insecurity and suicide ideation has been reported (Alaimo et al., 2002). In addition, a similar pattern of results has been reported for the relationships between experiencing food insecurity and suicide attempts (i.e., positive relationship (Alaimo et al., 2002), negative relationship (Altangerel et al., 2014) or no relationship (Maselko and Patel, 2008; Nagata et al., 2019). This inconsistency has even been observed among studies conducted in same study groups but from different geographical locations (Arat, 2017; Chung et al., 2016; Romo et al., 2016; Smith et al., 2022).

In view of these inconsistencies, the present study was designed to synthesize the findings in existing literature using a meta-analysis to determine the relationship between experiencing food insecurity and suicidal behaviors. Such aggregation of study results would be beneficial to formulate policies or suggest preventive guidelines to mitigate suicidal behaviours and other food insecurity-related problems. However, no studies have comprehensively synthesized the available literature despite reporting high prevalence of suicidal behaviors among individuals experiencing food insecurity. Therefore, for the first time, the present systematic review and meta-analysis was conducted with the following objectives to:

- Assess the prevalence of suicidal behaviors among individuals experiencing food insecurity.
- Identify the possible sources of heterogeneity. To do this, several subgroup analyses were

conducted in terms of country income by World bank classification (World Bank, 2022), continents, duration of food insecurity or suicidal behaviors experiences assessed, and type of measure used to assess food insecurity.

- Determine the association between food insecurity and suicidal behaviors.

Methods

Protocol and registration

The protocol for the present study was prospectively registered with PROSPERO (CRD42022352858) and the review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009), and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines for systematic reviews and meta-analysis (Stroup et al., 2000). The Joanna Briggs Institute (JBI) method and the CoCoPop (Condition, Context, and Population) were also used for forming the review questions and develop search strategy (Munn et al., 2015b). The *condition* was suicidal behavior (i.e., suicide ideation, plans, and attempts,), the *context* was global, and the *population* was individuals experiencing food insecurity. The review questions were: “*What is the pooled prevalence of suicidal behaviors among individuals experiencing food insecurity?*” and “*What is the association between experiencing food insecurity and suicidal behaviors?*”

Eligibility criteria

The eligible studies included peer-reviewed quantitative observational and interventional studies published in the English language regarding food insecurity experienced within the

past 12 months and suicidal behaviors within the past 12 months with no age restriction. The included studies either reported the prevalence/number of individuals with food insecurity experiencing suicidal behaviors and/or the association between experiencing food insecurity and suicidal behaviors. The exclusion criteria include case reports, letters to the editor, commentaries, policy papers, review papers, and metadata presentations. To establish recent association, studies reporting lifetime, childhood, or beyond 12 months experience of suicidal behaviors or food insecurity were also excluded.

Search strategy

The relevant databases including *Ovid databases* (i.e., *Embase*, *Global Health*, *APA PsycInfo*, *Ovid Emcare*, *Ovid Medline*, and *Epub Ahead of Print*), *PubMed*, *Web of Science*, and *CINAHL* were searched from inception to July 30, 2022. The following key words were used: suicidal behavior (i.e., “suicide, attempted” OR “suicidal ideation” OR “suicide plan” OR suicide) AND food insecurity (i.e., “food insecurity” OR hunger OR “food security” OR famine OR “food hardship” OR “food insufficiency”). A secondary search was also conducted to identify eligible studies from references of relevant papers.

Study and data management

All identified papers from the different databases were entered into the *Covidence website for review* to manage the following processes: (i) duplicate removal, (ii) title and abstract screening, (iii) full-text review, (iv) data extraction, and (v) quality assessment based on JBI Checklist for observational studies. The review process and steps were performed by two independent reviewers (i.e., MMK and RA - steps II to IV, while step V by IC and FB), and

ATO settled any disparities following a discussion with the two members at the various stages.

Data extraction

The following information was extracted from the included studies: the name of the first author, year of publication, study design, study group, countries where the study was conducted, sample size, number of participants below 18 years, number of male and female participants, years of data collection, number of individuals experiencing food insecurity, method for assessing food insecurity (self-report, record review, or validated tool), name of tool used to assess food insecurity, period of experiencing food insecurity assessed (days, weeks, 6 months, or 12 months), method used to assess suicidal behaviors (self-report, record review, and validated tool), tool used for assessing suicidal behaviors, duration of suicidal behaviors assessed (current, past week, past 2 weeks, past month, past 6 months, past 12 months), number of individuals with suicidal behaviors, number of individuals with suicidal behaviors experiencing food insecurity, and multivariate/adjusted odds ratio of the relationship between experiencing food insecurity and suicidal behaviors. For suicidal behaviors that were not reported in the three major categories (suicidal ideations, plan, and attempts) were classified as unspecified suicidal behaviors (e.g., reports of overall suicidal behaviors or any suicidal behavior experienced).

Risk of bias evaluation and quality assessment of the included papers

The nine-item JBI Checklist was used to evaluate the risk of bias and the quality of the included papers (Joanna Briggs Institute, 2017). The tool can be used for evaluation of both prevalence estimate and cumulative incidence studies (Munn et al., 2015a). The JBI Checklist uses a four-point response system: “no”, “yes”, “unclear”, and “not applicable”, for the following questions study characteristics: (i) appropriateness of the sample frame; (ii) recruitment procedure; (iii) adequacy of the sample size; (iv) description of participants and setting; (v) description of the identified sample; (vi) validity of the methods used to screen for food insecurity and/or suicidal behaviors; (vii) reliability of the methods used to screen for food insecurity and/or suicidal behaviors; (viii) adequacy of statistical analyses; and (ix) response rate. Papers were assigned one point for each ‘yes’ response and the remaining responses were assigned zero points. Therefore the total score ranged from 0 to 9. The scores of the studies are presented in **Supplementary Table 1**. The risk of bias in reporting the relationships was assessed using the JBI tool for analytical cross-sectional studies with a total score of 8 and the JBI tool for cohort studies with a total score of 11 (Aromataris, 2021). (**Supplementary Table 1**)

Data analysis

Data were analysed using the statistical software STATA version 17.0. Categorical data from the individual studies were summarized as frequencies and percentages, and numerical continuous as mean and standard deviation or median and interquartile range for parametric or non-parametric conditions, respectively. Heterogeneity across individual studies was assessed using Higgins’ inconsistency Q statistics and reported as I^2 and p -value.

For the pooled prevalence of suicidal behaviors, a random-effect model meta-analysis was performed for pooled outcomes and the corresponding I^2 . All results were presented as forest plots. A systematic narrative synthesis was performed to complete the meta-analysis. A p -value of <0.05 was considered statistically significant for all hypotheses testing. Publication bias was assessed visually using funnel plots symmetry (Sterne et al., 2011), fill and trim estimated the number of missing studies (Shi and Lin, 2019), and the Jackknife method determined the effect of individual studies on the pooled prevalence and sensitivity analysis for items within the funnel. Egger's test was also used to assess for small study effects. Univariate meta-regression was used to determine the source of heterogeneity based on continuous extracted study variables due to some studies having missing information. However, subgroup analysis was used for categorical variables such as countries' income level (World bank, 2022), continents, study group, study design, the method used to assess food insecurity, duration of food insecurity assessed, and duration of suicidal behaviors assessed.

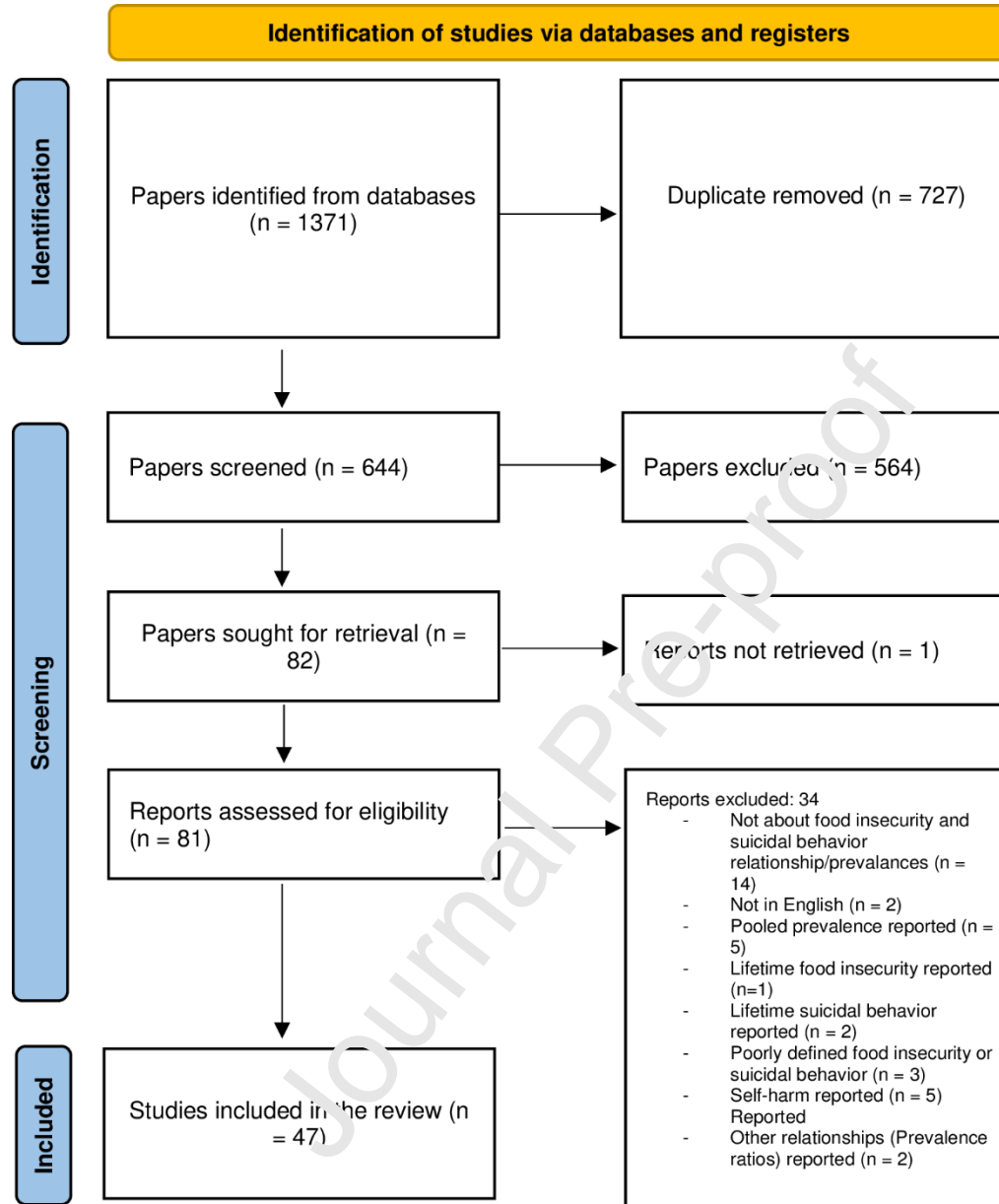
To analyze the relationship between experiencing food insecurity and suicidal behaviors, the fully adjusted odds ratio estimates following multivariate regression analysis were pooled. Risk ratios (RR) from were converted to odds ratio (OR) using the formula: $OR = ((1 - p) * RR) / (1 - RR * p)$, with an assumption that suicidal behaviors are rare (example in **Supplementary file 1**) (Grant, 2014). Where p is the prevalence of the outcome of interest in the population. Using the common-effect inverse-variance model of meta-analysis, the pooled odds ratio between experiencing food insecurity and suicidal behaviors (i.e., the odds between experiencing food insecurity and suicidal behaviors were transformed using natural

logs and the *metan* command was used to calculate the pooled prevalence). To accurately examine and explore the possible sources of heterogeneity among studies, subgroup analysis was performed based on the same categories as for prevalence.

Results

A total of 1,371 papers were identified from the databases. After the removal of duplicates ($k=727$), 644 papers remained and were screened based on their title and abstract. Following the screening, 82 papers qualified for full-text review (Fig 1). Among these, 35 papers were excluded. (Supplementary Table 2).

Figure 1: PRISMA flow diagram



A total of 47 studies comprising 388,966 individuals, with 75,346 having experienced food insecurity were included in the present review. The data reported in the included studies spanned a period between 1988 (Alaimo et al., 2002) and 2022 (Oh et al., 2022) and published between 2002 (Alaimo et al., 2002) and 2022 (Oh et al., 2022). A total of 203,394 males (169,259 females) and 113,589 adolescents were included in the studies. The majority

of the included studies were cross-sectional (92.74%), from lower- and middle-income countries [LMIC] (k = 24), and included adolescents still at school. The majority of the studies assessed both food insecurity and suicidal behaviors over a 12-month period (**Table 1**).

Table 1: Characteristics of the included studies[illegible]

										pec ified & FI)					
(Ala imo et al., 200 2)	US A (HI C) - NA	CS (19 88- 199 4)	754 (86)	Adole scents still in school (15-16 years old)	Self- report (curre nt/pr esent)	Pa st tw o we ek s	15 0 (23)		34 7 (17)	293 (52)	1.9 (0. 8- 4...		5.0 (1.7- 14.6)		Age, gend er, metr opolit an regio n, race- ethni city, famil y inco me, famil y head educ ation, famil y head

															empl oyme nt status , and famil y head marit al status
(Na gata et al., 201 9)	US A (HI C) – NA	CS (19 93- 200 8)	147 86 (16 47)	Gener al popul ation	Self- report (Past 12 mont hs)	Pa st 12 m ths	10 43 (28 0)		2.7 6 (2. 14- 3.5 5)		1.52 (0.86- 2.68)		Depr essio n, anxie ty or panic disor der, troub le fallin g aslee p in past 4 week s,		

														troub le stayi ng aslee p in past 4 week s
(Ma selk o and Pate l, 200 8)	Ind ia (L MI C) – Asi a	CS (20 01- 200 3)	231 8 (12 3)	Femal es	Self- report (Past 6 mont hs)	Pa st 12 m on ths			19 (5)			2.02 (0.46- 7.53)		Com mon ment al disor der, famil y in debt, Migr ant ethni city, youn g age at marri age, Expo

														sure to viole nce, Physi cal illnes s
(Ar at, 201 7)	Ug and a (LI C) – Afr ica Ke nya (L MI C) – Afr ica Za mbi	CS Ug an = 5 200 3 Ke nya = 200 3 Za mb ia = 200	Ug da = 321 5 (29 9) Ke nya = 369 1 (51 3) Za mb ia	Adole scents still in school	Self- report (Past 1 mont h)	Pa st 12 m on ths					Ug and a = 0.7 1 (0. 70- 0.7 4) Ke nya = 0.7 5 (0. 74- 0.7 6)	Ug and a = 1.3 9 (1. 36- 1.4 3) Ke nya = 1.6 9 (1. 67- 1.7 2)	Uganda = 0.71 (0.69- 0.73) Kenya = 0.58 (0.58- 0.59) Zambia = 0.88 (0.86- 0.90) Botswa na = 0.57 (0.54-	Age, gend er, bullyi ng, paren tal contr ol, and close frien ds

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C)	nia	7										0.63)		
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	lles (HI C) – Afr ica		143 2 (21 9)							8 (0. 80- 0.9 7)	0 (0. 33- 0.4 8)			
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										0.5 2 (0. 43- 0.6 3)	1.9 2 (1. 58- 2.3 0)			
(De win g et al., 201 3)	Sou th Afr ica (U MI C) – Afr ica	CS (20 06- 200 7)	249 (14 9)	Postpa rtum moth er	Val'd ated ool – the Hous ehold Food Insec urity Acces s Scale	Pa st m on th				19 (mi ssin g)			1.12 (1.0 2- 1.23)	Age, Incid ent self- repor ted HIV, Smok ing status , Marri

					(Past 12 mont hs)										ed, empl oyme nt, father of baby empl oyed, infor mal housi ng
(Ca bell o et al., 202 0)	Chi na (U MI C) – Asi a Gh ana (L MI C) –	CS (20 07)	18- 64 = 354 86 (46 46) Ab ove 64 = 188 54 (23	Gener al popul ation	Self- report (Past 12 mont hs)	Pa st 12 m onths	18- 64 = 95 8 (m issi ng) Ab ov e 64 =6 26		18- 64 = 24 9 (m issi ng) Ab ov e 64 = 11		18- 64 = 1.6 4 (1. 38- 1.9 7) Ab ove 64 = 144		18-64 = 2.22 (1.60- 3.08) Above 64 = 1.69 (1.00- 2.85)		Coun try, gend er, age, educ ation, marit al status , hous ehold inco me,

[illegible]

[illegible]

	Africa (UMIC) – Africa														
(Davis et al., 2015)	Canada (HIC) – NA	CS (2007)	5270 (1041)	General population	Validated tool (Past 12 months) <i>The Household Food Security Survey Module</i>	Participant	1014 (315)				Moderate FI = 1.32 (1.06-1.64) Severe FI = 1.77 (1.42-				Sex, age, education, relationship status, household income, employment status, mood disorder

											2.2 3)				der, body mass index .
(Nj unj u et al., 201 7)	My an mar (L MI C) - Asi a	CS (20 07)	280 3 (91)	Adole scents still in school	Self- report (Past 12 mont hs)	Pa st 12 m on ths	30 (m issi ng)				2.0 3 (1 96- 1.1 1)				Age, anxie ty, loneli ness, close frien ds' prese nce, truan cy, bullie d, attac ked, in a fight, consu med alcoh ol, paren

															tal under stand ing
(Ro mo et al., 201 6)	Ecu ado r (U MI C) – S.A	CS (20 07)	552 4 (22 00)	Adole scents still in school (12-15 years old)	Valid ated tool (Past 1 mont h) <i>GSHS</i> <i>core</i> <i>questi</i> <i>onnair</i> <i>e</i> <i>modul</i> <i>es/ Di</i> <i>ary</i> <i>Behav</i> <i>iours</i> <i>Modul</i> <i>e</i>	Pa st 12 m on ths	31 8 (14 6)	55 1 (27 3)			FI rar e = 1.1 4 0. 84- 1.5 5)	FI rar e = 1.1 3 (0. 86- 1.5 0)			Low paren t/gua rdian invol veme nt, peer victi mizat ion, age, gend er, city of reside nce
											FI alw	FI alw			

											ays = 1.5 2 (0. 55- 4.2 1)	ays = 2.9 1 (1. 58- 5.3 4)		
(Sm ith et al., 202 2)	Chi na (U MI C) – Asi a, Gh ana (L MI C) – Afr ica, Ind ia	CS (20 07- 201 0)	341 29 (40 28)	Older person s (above 50 years)	Self- report	Pa st 12 m on ths	11 61 (34 3)		20 5 (8%	Mo der ate FI = 1.3 5 (0. 9- 2.0 2) Sev ere FI = 2.7 8 (1. 73-		Moderat e FI = 2.59 (1.35- 4.97) Severe FI = 5.15 (2.52- 10.53)		Coun try, sex, age, wealt h, educ ation, empl oyme nt, alcoh ol consu mpti on, physi cal activi ties,

	(L MI C)- Asi a Me xic o (U MI C) - S.A Rus sia (HI C) - Eur ope Sou th Afr ica (U									4.4 5)					self- rated healt h,
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	MI C) – Afr ica														
(Yan g, 201 5)	Korea (HIC) – Asia	CS (2008- 2010)	445 1 (3033)	Older person s (65- 98 years in the Korea Natio nal Health and Nutriti on Exam ination Surve y)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	11 46 (88 7)								
(Kwang u et al., 201	Pakistan (LMIC)	CS (2009)	519 2 (311)	Adole scents still in school	Self- report (Past 12 mont	Pa st 12 m on	37 5 (m issi ng)				1.2 4 (1. 22- 1.2				Age, gend er, anxie ty,

7c)	C)- Asi a				hs)	ths					5)				loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, smok ed cigar ettes, paren ts under stand ing
(M wa mbe ne et al.,	Ma law i (LI C) –	CS (20 09)	235 9 (28 7)	Adole scents still in school (below 15	Self- report (Past 12 mont hs)	Pa st 12 m on ths	29 4 (53)								

2013)	Africa			years involved in the GSHS)											
(Altangrel et al., 2014)	Mongolia (LIC) - Asia	CS	5191 (1787)	Adolescents still in school (12-18 years involved in the GSHS)	Self-report (Past 12 months)	Pa	1017 (440)	650 (296)	449 (224)		0.77 (0.65-0.91)	0.72 (0.60-0.88)	0.67 (0.53-0.85)		Gender, grade, location and living condition
(Kinnyanda et al., 2012)	Uganda (LIC) - Africa	CS	618 (69)	HIV patients	Self-report (Past 12 months)	Pa				48 (10)				2.26 (1.06-4.84)	Age and sex
(Kwang'u et	Philippines	CS	5290 (37)	Adolescents still in	Self-report (Past	Pa	857 (m				1.06 (1.				Age, gender,

al., 2017a)	(L MI C) – Asi a		5)	school (GSH S)	12 mont hs)	m on ths	issi ng)				05- 1.0 6)					anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, smok ed cigar ettes, paren ts under stand ing, consu med alcoh ol,
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															abuse d alcoh ol
(Ma zab a et al., 201 7b)	Fiji (U MI C) - Oc ean ia	CS (20 10)	167 3 (17 6)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	29 5 (m issi ng)				1.0 6 (1. 0, 1.1)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, smok ed cigar ettes, alcoh ol

															use, abuse d alcoh ol
(Ma zab a et al., 201 7a)	We st Ban k (L MI C) – Asi a	CS (20 10)	190 8 (16 6)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	42 3 (m issi ng)				1.5 1 (1 45- .5 6)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, smok ed cigar ettes, paren

															ts under stand ing
(Mu leng a et al., 201 7c)	Ga za Stri p (L MI C) – Asi a	CS (20 10)	260 7 (30 3)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	49 6 (m issi ng)				1.1 3 (1. 09 1.1)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, smok ed cigar ettes, paren ts

															under stand ing
(Mu leng a et al., 201 7b)	Mo roc co (L MI C) – Afr ica	CS (20 10)	292 4 (30 2)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	48 1 (m issi ng)				1.0 6 (1. 05- 1.7 7)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, smok ed cigar ettes, paren ts under

															stand ing, marij uana
(Siz iya et al., 201 7b)	Ja mai ca (U MI C) – S.A	CS (20 10)	162 3 (16 7)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	34 3 (m issi ng)				1.4 4 (1. 4, 1.4)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, curre ntly smok ed, paren ts under stand ing, curre

														nt alcoh ol use, abuse d alcoh ol
(Ab raha ms et al., 201 8)	Sou th Afr ica (U MI C) – Afr ica	CS (20 11- 201 2)	376 (15 8)	Pregn ant wome n	Valid ated tool (Past six mont hs) <i>The US House hold Food Securi ty Surve y Modul e (HFS SM):</i>	Pa st m on th	47 (19)			24 (10)			5.34 (1.2 6- 22.5 7)	Perso nal inco me, empl oyme nt, hous ehold inco me, numb er of childr en, depre ssion, anxie ty, ment

					6-Item Short Form												al illnes s histor y, threat ening life event s, intim ate partn er viole nce, perce ived social supp ort, subst ance depe nden ce, alcoh ol
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															depe nden ce
(Ma zab a et al., 201 7c)	Ku wai t (HI C) – Asi a	CS (20 11)	267 2 (24 0)	Adole scents still in school	Self- report (Past 12 mont hs)	Pa st 12 m on ths	51 9 (m issi ng)				1.0 6 (1. 02- 1. 0)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, curre ntly smok ed cigar ettes, paren

														ts under stand ing, used marij uana
(Mu leng a et al., 201 7d)	Tri nid ad and To bag o (HI C) - SA	CS (20 11)	281 1 (21 2)	Adole scents still in school	Self- report (Past 12 mont hs)	Pa st 12 m on ths	44 3 (m issi ng)				1.2 8 1.1 22- 1.3 5)			Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, curre ntly smok

															ed cigar ettes, paren ts under stand ing, used marij uana, alcoh ol abuse , curre ntly used alcoh ol
(Pry or et al., 201 6)	Fra nce (HI C) – Eur ope	Co hor t (20 11)	110 9 (94)	The genera l popul ation (Aged 18 – 35	Valid ated tool (Past 12 mont hs) <i>Cornel</i>	Pa st 12 m on ths	51 (11)				3.2 3 (1. 56 – 6.7 2)				Depr essio n, ADH D, Subst ance use,

				years- Youn g adults- TEM PO (Traje ctoires EÂ' pideÂ' 'miolo giques en Popul ation)	<i>l- Radi mer hunge r scale and the USD A 10- item questi onnair e</i>									and como rbid ment al condi tions
(Siz iya et al., 201 7a)	Sa mo a (L MI C) – Oc ean ia	CS (20 11)	241 8 (82 5)	Adole scents still in school 'mont hs)	Self- report 'Part 12 mont hs)	Pa 61 8 (m issi ng) ths				1.1 0 (1. 00- 1.2 1)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie

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(Chung et al., 2016)	Korea (HIC) – Asia	CS-2013)	5862 (449)	The general population (Korea National Health and Nutrition Examination Survey 2012–2013);	Validated tool (Past 12 months)	Patient information	436 (63%)				FII household hold with household with household with household					Sex, age, income, education, alcohol use, smoking status, physical activity, marital status, and recipients of food assistance.
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											3.8 3 (2. 02- 7.2 3)				
(Kw ang u et al., 201 7b)	Gh ana (L MI C) – Afr ica	CS (20 12)	164 8 (24 6)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on ths	32 8 (m issi ng)				1.0 9 (1. 8- 1.1 0)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, curre ntly smok ed

															cigar ettes, paren ts under stand ing, alcoh ol abuse , curre ntly used alcoh ol
(Mu leng a et al., 201 7a)	Ira q (U MI C) – Asi a	CS (20 12)	202 7 (17 4)	Adole scents still in school (GSH S)	Self- report (last 12 mont hs)	Pa st 12 m on ths	34 5 (m issi ng)				1.0 7 (1. 06- 1.0 8)				Age, gend er, anxie ty, loneli ness, close frien ds', truan cy,

															bullied, attacked, in a fight, currently smoked, parents understanding
(Nii - Boye Quarshiye and Andoh-Artur, 202	Ghana (LMIC) – Africa	CS (2012)	1437 (909)	Adolescents still in school	Self-report (Past 12 months)	Parent 12 months			396 (282)				1.10 (0.78-1.54)		Age, gender, grade, loneliness, anxiety, alcohol use, paren

2)															t under stand ing, paren t moni torin g, home work check ing, truanc y, bullyi ng victi misat ion, social supp ort at school, being sexua lly
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															active , numb er of close frien ds, physi cal fights
(Op pon g Asa nte et al., 201 7)	Gh ana (L MI C) – Afr ica	CS (20 12)	198 4 (26 1)	Adole scents still in school (GSH S aged <15)	Self- report (Past 12 month hs)	Pa st 12 m th	36 0 (77)	43 8 (52)	42 8 (36)		1.5 6 (1. 09- 2.2 3)	1.6 1 (1. 15- 2.4 6)	1.48 (1.05- 2.09)		Age, gend er, anxie ty, loneli ness, truan cy, bullie d, attac ked, in a fight, close frien ds,

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																free time, paren t intrus ion of priva cy
(Tee vale et al., 201 6)	Ne w Zea lan d (HI C) – Oc ean ia	CS (20 12)	144 5 (85 0)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on th			16 1 (12 2)				FI occasio nally/so metimes = 1.126 (0.641- 1.979) FI often/al l the time = 1.757 (0.973- 3.173)		Gend er, famil y moni torin g, famil y conn ectio n, healt h seeki ng, life satisf actio n,	

															religion and spirituality, suicide connection with friend or family
(Alman sour and Siziya, 2017)	Swaziland (LMI – Africa)	CS (2013)	3680 (3345)	Adolescents still in school (GSHS)	Self-report (Last 12 months)	Participant 12 (missing)	626				1.23 (1.18-1.28)				Age, gender, anxiety, loneliness, close friends', truancy,

															bullied, attacked, in a fight, ever use drugs, ever use marijuana, parents understanding
(Ju et al., 2016)	Korea (HIC) – Asia	CS (2013)	58590 (65-58)	Older person (above 65 years)	Self-report (Past 12 months)	Parent (12 months)	9265 (20-70)				Ma				Household income, living arrangements, age, education

											Fe ma les = 1.3 6 (1. 2 1.4)					ation level, empl oyme nt status , recei pt of basic liveli hood aid, perce ived healt h status , limits of activi ties of daily living , smok
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(Ma zab a et al., 201 7d)	Vie tna m (L MI C) – Asi a	CS (20 13)	333 1 (34)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on th	53 8 (m issi ng)				0.6 8 (0. 67- 0.6 9)				Age, gend er, loneli ness, close frien ds', truan cy, bullie d, attac ked, in a fight, curre ntly smok ed cigar ettes, used marij uana, paren ts

															under stand ing, alcoh ol abuse , curre ntly consu med alcoh ol
(Zia ei et al., 201 7)	Ira n (L MI C) – Asi a	CS (20 13- 201 4)	151 7 (89 4)	Adole scents still in school (GSH S)	Self- report (Past 12 month s)	Pa et 12 month th	62 (m issi ng)				4.1 5 (1. 71- 10. 07)				Age, gend er, loneli ness, hard time focus ing on work, smok ing, ideas of

															alcohol use, bullied, sexually abused, understanding parents
(Shayo and Lawala, 2019)	Tanzania (LMI-C) – Africa	CS (2014)	3793 (254)	Adolescents still in school (Primary and secondary school students aged 13-17	Validated tool (Part 1 month)	Part 1	536 (61)	422 (67)			1.8 (1.3-2.5)		2.4 (1.7-3.3)		Age, loneliness, anxiety, parental care, gender, school level

				years)	2017)- Dietary behaviors module										
(Pa nde y et al., 201 9)	Ne pal (L MI C) – Asi a	CS (20 15)	653 1 (26 3)	Adole scents still in school (GSH S)	Self- report (Past 12 mont hs)	Pa st 12 m on th	78 1 (m issi ng)		57 2 (m issi ng)		2.5 2 1.62- 3.3 2)		1.84 (0.73- 4.66)		Paren t supp ort score, anxie ty, loneli ness, close frien ds, bullie d, physi cally attac ked, physi cal fight,

															current cigarette use, initiation of drug use, really drunk, parent check homework, parent monitoring, gender
(Bantjes et	South Afr	CS (2016-	647 (263)	Males	Validated tool	Parent 12				47 (31)				1.099 (0.9	Age, has toilet

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(De ma et al., 201 9)	Bh uta n (L MI C) – Asi a	CS (20 16)	580 9 (17 69)	Adole scents still in school (13-17 years)	Self- report (Past mont h)	Pa st 12 m on th	66 7 (26 8)		65 6 (29 8)						
(Du mit h et al., 202 0)	Bra zil (U MI C) – S.A	CS (20 16)	129 5 (45 4)	Gener al popul ation	Valid ated tool (Past 6 mont hs) <i>Brazili an Scale of Food Insecu rity and</i>	Pa st 2 we ek s	86 (48)								

					<i>Hunger in Brazil (EBIA).</i> A score above 0										
(Fit zpat rick and Spia lek, 202 0)	US (HI C) – NA	CS (20 17)	316 (mi ssi ng)	Hurric ane Harve y surviv ors	Valid ated tool (Past 12 mont hs) – items from the US Food Secur ity surve y Mod ule	Pa st 12 m on ths	33 (m issi ng)				1.2 1. 0- 1.5)				Age, gend er, impa ct of event scale, prior ment al healt h, religi ous social capac ity, com muni ty

															connectedness, optimism
(Be ksin ska et al., 2021)	Kenya (LMIC) – Africa	CS	1003 (331)	Female sex workers	Self-report (Past week)	Pa st m on th				101 (58)					
(McAuliffe et al., 2021)	Canada (HIC) – NA	CS	2903 (503)	General population	Self-report (Past week)	Pa st tr we ek s	170 (65)				1.87 (1.24-2.80)				Age, gender, household income, indigenous, parent/guardian living

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														result of the COV ID- 19 pand emic.
(Pe ngpi d and Pelt zer, 202 0)	Ja mai ca (U MI C) – S.A	CS (20 17)	274 4 (43 9)	Adole scents still in school (GSH S)	Recor d revie w	Pa st 12 m on ths			92 5 (18 9)				Single suicide attempt = 1.25 (0.67- 2.35) Multiple suicide attempts = 1.06 (0.54- 2.09)	Age, gend er, numb er of frien ds, loneli ness, anxie ty, frequ ency of being bullie d, frequ ency of physi

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															soft drink intake, fast food intake, multiple sexual patterns, multiple injuries/
(Oh et al., 202 2)	US A (HI C) – NA	CS (20 20- 202 1)	963 79 (29 729)	Colleg e students	Self report (Past 12 month hs)	Pa st 12 m on ths	82 90 0 (23 34 7)	55 91 (27 90)	13 57 (82 7)		1.5 8 (1. 47- 1.7 0)	1.6 0 (1. 45- 1.7 7)	2.27 (1.83- 2.81)		Age, gend er, race/ ethni city, finan cial distre ss, and

															paren tal educ ation.
(Ny und o et al., 202 0)	Eth iopi a (LI C) – Afr ica Ke nya (L MI C) – Afr ica, Ug and a (LI C) –	CS ()	766 2 (66 6)	Adole scents still in school	Self- report (Past 12 mont hs)	Pa st 12 m on ths	29 0 (m issi ng)	16 2 (m issi ng)	13 5 (m issi ng)	308 (mi ssin g)				Ethi opi a (Ha rar) = 2.64 (1.3 6 - 5.13) Nig eria (Iba nda) = 1.0 (0.7 8 - 1.29)	Age, sex, schoo l status , empl oyme nt, paren ts alive, living with both paren ts, wealt h index quint ile, bullie d,

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Journal Pre-proof

NA – North America, SA – South America, HIC – High-income Country, UMIC – Upper middle-income country, LMIC – Lower middle-income country, LIC – Low-income country, CS – Cross-sectional study, FI – Food insecurity, SI – Suicide ideation, SP – Suicide plans, SA – Suicide attempts, SB. Suicide behaviour, GSHS – Global School Health Survey

Excluded at full-text review due to having other relationships such as PR(Fitzpatrick et al., 2020), beta coefficients (Brown et al., 2022)

Quality assessment of the included papers

All the included studies, scored well on the JBI for prevalence studies. However, the tools used for assessing both suicidal behaviors and food insecurity in most studies were not validated. Most studies relied on self-reports of the two main measures, making the possibility of recall bias high. Adequate samples were used and robust methods were used (Supplementary Table 1).

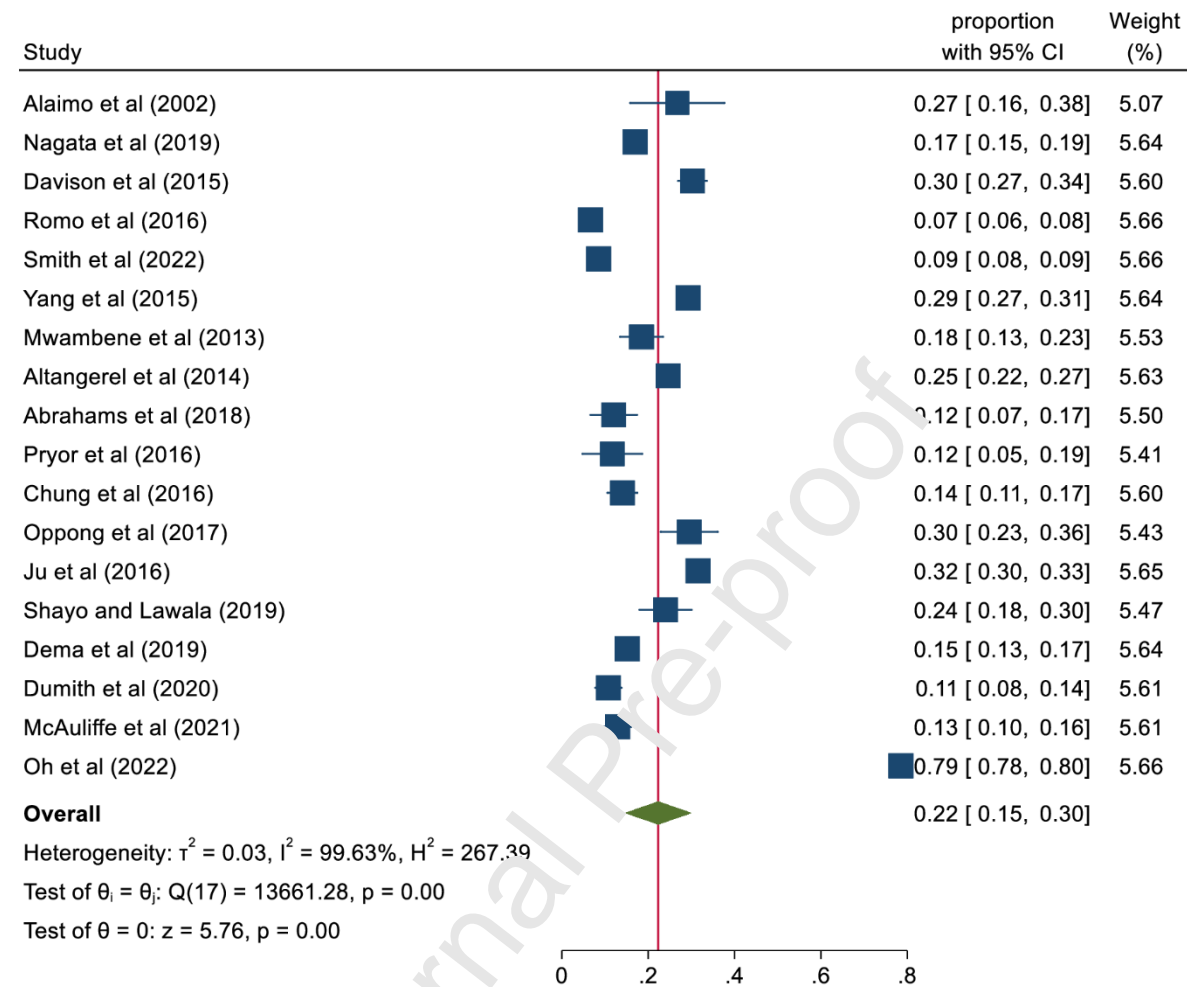
Prevalence of suicidal behaviors

Suicidal ideation

A total of 18 studies provided the prevalence/number of individuals with suicidal ideation experiencing food insecurity (Abrahams et al., 2018; Alaimo et al., 2002; Altangerel et al., 2014; Chung et al., 2016; Davison et al., 2015; Dema et al., 2019; Dumith et al., 2020; Ju et al., 2016; McAuliffe et al., 2021; Mwambene et al., 2013; Nagata et al., 2019; Oh et al., 2022; Oppong Asante et al., 2017; Piro et al., 2016; Romo et al., 2016; Shayo and Lawala, 2019; Smith et al., 2022; Yarg, 2015). The studies were from a total sample of 250,564 individuals. Out of these, 54,313 individuals reported food insecurity, and 100,661 reported suicidal ideations. A total of 28,517 reported having both suicidal ideation and food insecurity. The studies were published between 2002 (Alaimo et al., 2002) and 2022 (Oh et al., 2022; Smith et al., 2022), and data were collected between 1988 (Alaimo et al., 2002) and 2020 (Oh et al., 2022). The prevalence of suicidal ideation ranged between 6.6% (Romo et al., 2016) and 78.5% (Oh et al., 2022), and the pooled prevalence of suicidal ideation was 22.3% (95% CI: 14.7%-29.9%; $I^2 = 99.6\%$, $p < 0.001$) (Fig 2).

Fig. 2: Forest plot for the pooled prevalence of suicide ideations among individuals with

food insecurity



Heterogeneity source identification tests

Based on the I^2 , and visual inspection from the funnel plot (**Supplementary Fig. 1**) there was obvious heterogeneity, with only four studies being within the funnel. Based on leave one out analysis (Jackknife method), none of the studies had a significant effect on the overall pooled prevalence (**Supplementary Fig. 2**). There was no small study effect based on Egger's test. Beta = -1.30 (Standard error [SE] = 3.1), $p = 0.670$. However, there were four missing studies based on trim and fill analysis.

Subgroup analysis and meta-regression

Univariate meta-regression analysis was conducted using the number of males, and females, participants below 18 years, and sample size (**Table 2**). The heterogeneity significantly increased with an increase in the overall sample size and the total number of male participants in the overall sample in terms of suicidal ideation.

Table 2: Univariate meta-regression analysis for suicidal behavior

Variable	Suicide ideation			Suicide plans			Suicide attempts			Suicidal behavior unspecified		
	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value
Overall sample size	4.91e-06	1.05e-06	<0.001	-1.34e-06	1.46e-06	0.357	-2.42e-06	1.33e-06	0.068	4.2e-5	4.71e-5	0.372
Total number of females in the overall sample	7.26e-06	4.23e-06	0.036	-8.70e-06	8.04e-06	0.279	-1.35e-05	5.04e-06	0.0007	8.97e-06	3.26e-5	0.783
Total number of males in the overall	7.54e-06	1.17e-06	<0.001	-1.61e-06	1.81e-06	0.374	-2.62e-06	1.75e-06	0.134	1.25e-5	4.3e-5	0.772

sample												
Total number of individuals below 18 years	- 1.29e- 05	1.86 e-05	0.4 87	- 3.94e- 06	.000 0304	0.8 97	1.92e- 5	1.98 e-5	0.3 31	4.6e-5	2.86 e-5	0.1 08
JB1 score for prevalence/ incidence estimates	-0.125	0.07 4	0.0 92	-0.077	0.15 2	0.6 10	-0.012	0.08 7	0.8 94	0.017	0.01 9	0.3 75

Using subgroup analysis (**Table 3**), the following factors were significantly responsible for the increase in the heterogeneity: country, income level, continent, study population, and period of food insecurity assessed. High income countries (HIC) had a higher prevalence of suicidal ideation among individuals experiencing food insecurity than countries from other income levels (i.e., 28.1% in HIC, 22.9% in LMICs [low and middle-income countries], 18.5% in LIC [low-income countries], and 9.2% in UMICs [upper middle-income countries]). Similarly, the North American continent had a significantly higher prevalence of suicidal ideation among individuals experiencing food insecurity compared to other continents (33.2% in North America, 23.0% in Asia, 20.8% in Africa, 11.7% in Europe, and 8.5% in South America). A past 12 months' history of experiencing food insecurity had a higher prevalence of suicidal ideation compared to other periods assessed.

Table 3: Subgroup analysis for the pooled prevalence of suicidal behavior

Variable	Sub-groups	Suicide ideation			Suicide plans			Suicide attempts			Suicidal behavior unspecified		
		Numer of studies	Pooled prevalence (95% Confidence interval)	Test of difference Q (p-value)	Numer of studies	Pooled prevalence (95% Confidence interval)	Test of difference Q (p-value)	Numer of studies	Pooled prevalence (95% Confidence interval)	Test of difference Q (p-value)	Numer of studies	Pooled prevalence (95% Confidence interval)	Test of difference Q (p-value)
Study design	Cohort	2	15.4 (10.7-20.2)	2.5 (0.110)	0	N/A	N/A	2	3.7 (2.8-4.6)	14.8 (<0.001)	N/A	N/A	N/A
	Cross-sectional	16	23.3 (14.9-31.7)		4	26.1 (10-28.1)		10	19.9 (11.7-28.2)		5	4.6 (2.8-6.4)	
Country income status	High-income countries	9	28.1 (14.5-41.7)	22.8 (<0.001)	1	9.4 (9.0-9.7)	18.3 (<0.001)	4	9.3 (1.7-17.0)	48.6 (<0.001)	1	6.9 (5.0-8.8)	36.8 (<0.001)
	Upper middle-income countries	3	9.2 (2.8-12.6)		1	12.4 (10.9-13.9)		1	43.1 (36.9-49.2)		2	4.6 (3.3-5.9)	
	Lower middle-income countries	4	22.9 (16.8-28.9)		2	25.8 (7.1-44.4)		6	20.4 (11.3-29.5)		1	5.8 (4.3-7.3)	
	Low-income	1	18.5 (13.5-		0	N/A		0	N/A		1	1.6 (0.6-	

	countries		23.4)									2.6)	
Continent	Africa	4	20.8 (13.6-28.1)	19.9 (0.001)	1	35.6 (28.4-42.9)	115.8 (<0.001)	3	30.4 (27.5-33.3)	129.6 (<0.001)	4	4.0 (2.2-5.9)	4.4 (0.035)
	Asia	5	23.0 (16.0-30.0)		1	16.6 (14.7-18.5)		3	11.3 (4.1-18.5)		0	N/A	
	Europe	1	11.7 (4.8-18.6)		0	N/A		0	N/A		0	N/A	
	North America	5	33.2 (9.9-56.5)		1	9.4 (9.0-9.7)		3	7.7 (-2.0-17.4)		1	6.9 (5.0-6.1)	
	South America	2	8.5 (4.4-12.5)		1	12.4 (10.9-13.9)		1	43.1 (36.9-49.2)		0	N/A	
	Oceania	0	N/A		0	N/A		1	14.4 (11.8-16.9)		0	N/A	
Study population	Adolescents still in school	7	20.2 (14.1-26.2)	1302.5 (<0.001)	3	21.1 (7.5-34.7)	2.9 (0.091)	8	24.4 (17.0-31.8)	42.2 (<0.001)	1	6.9 (5.0-8.8)	62.41 (<0.001)
	Caregivers of HIV patients	0	15.5 (0.9-18.0)		0	N/A		0	N/A		0	N/A	
	Older persons	3	23.1 (8.7-37.5)		0	N/A		1	2.2 (1.8-2.7)		0	N/A	
	General population	6	16.2 (10.4-		0	N/A		1	3.6 (2.7-		0	N/A	

	n		22.1)						4.6)				
	Pregnant women	1	12.0 (6.6-17.4)		0	N/A		0	N/A		1	4.3 (2.2-6.3)	
	College students	1	78.5 (77.5-79.5)		1	9.4 (9.0-9.7)		1	2.8 (2.6-3.0)		0	N/A	
	Females	0	N/A		0	N/A		1	4.1 (0.5-7.6)		1	5.8 (4.3-7.3)	
	Males	0	N/A		0	N/A		0	N/A		1	4.8 (3.1-6.5)	
	HIV patients	0	N/A		0	N/A		0	N/A		1	1.6 (0.6-2.6)	
	Method of assessing food insecurity	Self-report	11		26.6 (15.3-37.8)	2.8 (0.095)		3	20.2 (5.1-35.2)		1.01 (0.315)	10	
Validated tools		7	15.6 (9.2-21.9)	1	12.4 (10.9-13.9)		1	26.4 (20.1-32.7)	2	4.6 (3.3-5.9)			
Record review		N/A	N/A	N/A	N/A		1	43.1 (36.9-49.2)	0	N/A			
Period of food insecurity	Current/present	1	26.7 (15.8-37.7)	12.2 (0.011)	0	N/A	0.56 (0.454)	1	19.8 (10.4-29.2)	19.0 (<0.001)	1	6.9 (5.0-8.8)	5.9 (0.118)
	Past week	1	12.9 (9.8-		0	N/A		0	N/A		1	5.8 (4.3-	

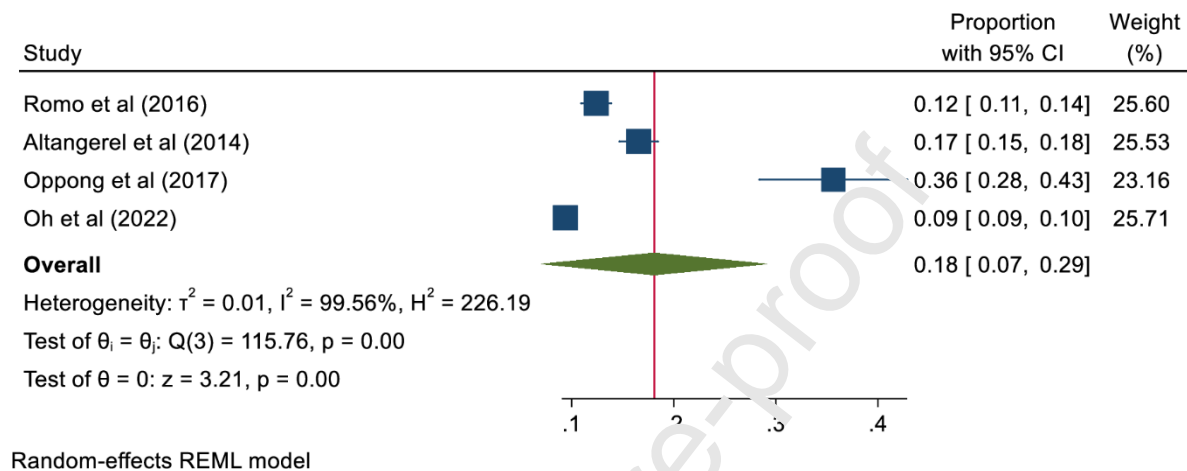
assess			16.1)									7.3)	
ed	Past month	3	14.9 (5.3-24.6)		1	12.4 (10.9-13.9)		3	28.6 (13.5-43.6)		2	3.1 (0-6.2)	
	Past 6 month	2	11.1 (8.4-13.7)		0	N/A		1	4.1 (0.5-7.6)		1	4.3 (2.2-6.3)	
	Past 12 months	10	26.9 (14.4-39.4)		2	22.2 (-3.5-48.0)		6	14.3 (3.0-25.6)		0	N/A	
Durat	Past 2 weeks	3	15.3 (7.3-27.9)	4.9 (0.08-5)	0	N/A	N/A	1	11.8 (10.4-29.2)	0.19 (0.66-7)	1	6.9 (5.0-8.8)	4.5 (0.10-4)
ion of	Past month	1	12.0 (6.6-17.4)		0	N/A		0	N/A		2	5.2 (3.7-6.7)	
suicid	Past 12 months	14	24.3 (14.9-33.6)		4	18.1 (7.0-28.1)		11	17.0 (8.7-25.3)		2	3.1 (0-6.2)	
e													
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Suicide plans

A total of four studies provided the prevalence/number of individuals having a suicide plan among individuals experiencing food insecurity (Altangerel et al., 2014; Oh et al., 2022; Oppong Asante et al., 2017; Romo et al., 2016). The studies were from a total sample of 109,078 individuals. Out of these, 33,977 individuals reported experiencing food insecurity, and 7,230 reported having suicide plans. A total of 3,452 reported having both suicide plans and food insecurity. The studies were published between 2014 (Altangerel et al., 2014) and 2022 (Oh et al., 2022) and the prevalence of suicide plans ranged between 9.4% (Oh et al., 2022) and 35.6% (Oppong Asante et al., 2017). The pooled prevalence of suicide plans was

18.1% (95% CI: 7.0%-29.1%; $I^2 = 99.6\%$, $p < 0.001$) (**Fig 3**).

Fig. 3: Forest plot for the pooled prevalence of suicide plans among individuals with food insecurity



Heterogeneity source identification tests

The I^2 was above 50%, and none of the studies were within the funnel plot (**Supplementary Fig. 3**). However, based on trim and fill, there were no missing studies to be imputed. The leave-one-out meta-analysis indicated that the pooled prevalence was reduced by a study conducted by (Oppong Asante et al., 2017) (**Supplementary Fig. 4**). Sensitivity analysis was conducted without the study by (Oppong Asante et al., 2017) and the corrected pooled prevalence of suicide plan was 12.7% (95% CI: 8.6-16.8; $I^2 = 97.1\%$ $p < 0.001$).

Subgroup analysis

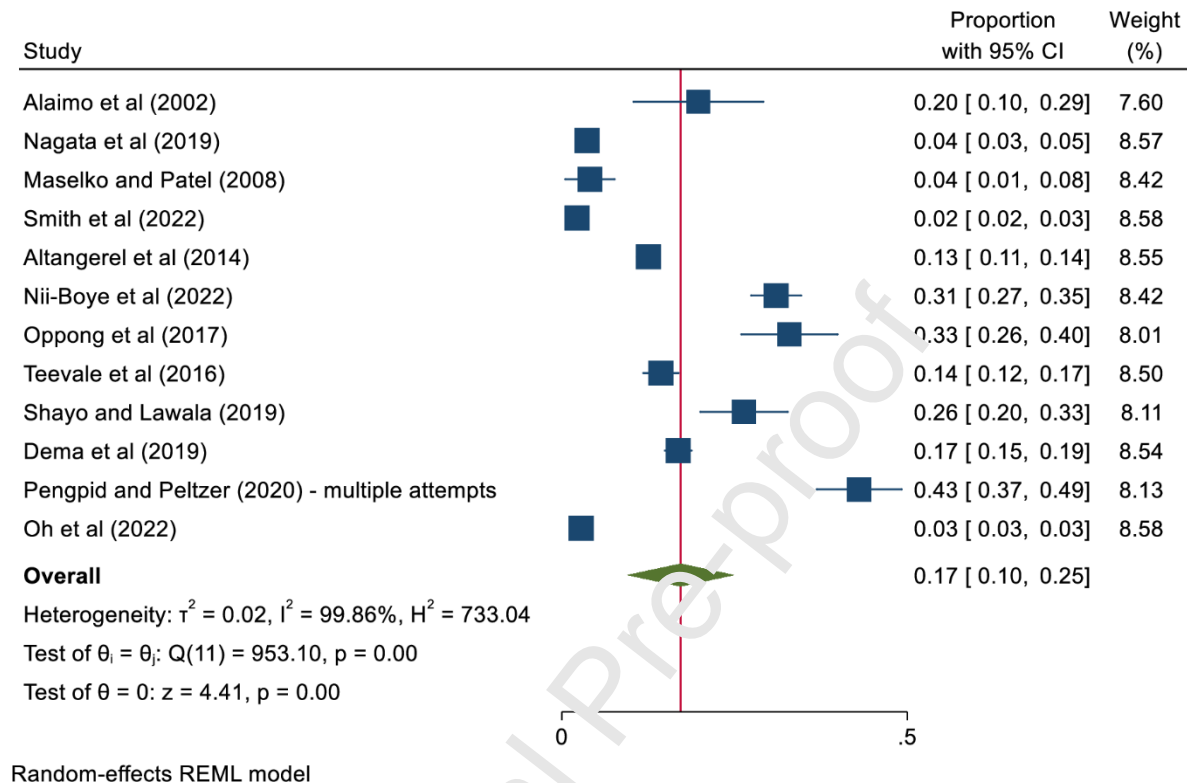
The pooled prevalence of suicide plans increased as the country's income status decreased, with HICs having the lowest prevalence. The pooled prevalence was highest in the African continent followed by Asia, with South America and North America having lower

prevalence.

Suicide attempts

A total of 12 studies reported the prevalence estimate/number of individuals with suicide attempts among individuals experiencing food insecurity (Alaimo et al., 2002; Altangerel et al., 2014; Dema et al., 2019; Maselko and Patel, 2008; Nagata et al., 2019; Nii-Boye Quarshie and Andoh-Arthur, 2022; Oh et al., 2022; Oppong Asante et al., 2017; Pengpid and Peltzer, 2020; Shayo and Lawala, 2019; Smith et al., 2022; Teevale et al., 2016). The studies were from a total sample of 170,769 individuals (overall sample). Out of these, 41,882 individuals reported experiencing food insecurity, and 5,619 reported suicide attempts. A total of 2,266 reported having both suicide attempts and food insecurity. The studies were published between 2002 (Alaimo et al., 2002) and 2022 (Nii-Boye Quarshie and Andoh-Arthur, 2022; Oh et al., 2022, Smith et al., 2022) and the prevalence of suicide attempts ranged between 1.5% (Dema et al., 2019) and 33.0% (Oppong Asante et al., 2017). The pooled prevalence of suicide attempts was 17.2% (95% CI: 9.6%-24.8%; $I^2 = 99.9\%$, $p < 0.001$) (**Fig 4**).

Fig. 4: Forest plot for the pooled prevalence of suicide attempts among individuals with food insecurity



Heterogeneity source identification tests

There was significant heterogeneity ($I^2 = 99.9\%$). In addition, only two studies were within the funnel plot (**Supplementary Fig. 5**) with obvious asymmetry having most studies distributed to the right of the funnel. The Egger's test indicated a small sample size study effect ($\beta = 6.56$, $SE = 2.012$, $p = 0.001$). However, based on trim and fill, there were no missing studies to be imputed. The leave-one-out meta-analysis indicated that the pooled prevalence was not significantly affected by the removal of any of the studies (**Supplementary Fig. 6**).

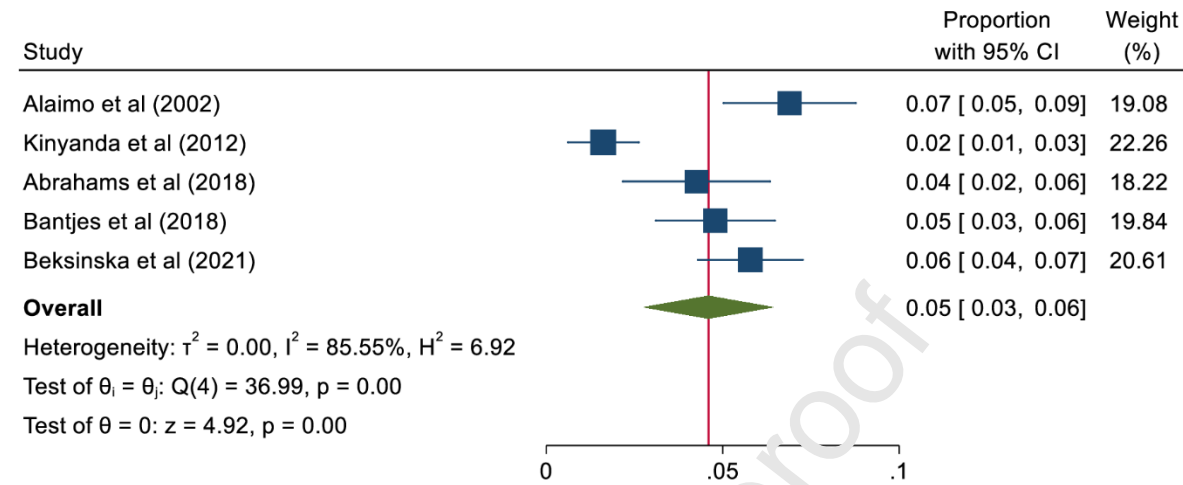
Subgroup analysis and univariate meta-regression

Females were associated with a reduction in heterogeneity (**Table 2**). In subgroup analysis (**Table 3**), the prevalence of suicide attempts was different in the following groups: countries' income status, continent, study population, method for assessing food insecurity, and period of food insecurity assessed. HICs and North America had the lowest suicide attempt prevalence among these categories of income status and continent. Adolescents still in school had the highest level of suicide attempts compared to other study groups. Individuals who reported experiencing food insecurity by self-report had the lowest level of suicide attempts and those who reported experiencing food insecurity for the past month had the highest level of suicide attempts.

Unspecified suicidal behaviors

A total of five studies reported the prevalence of unspecified suicidal behaviors among individuals experiencing food insecurity (Abrahams et al., 2018; Alaimo et al., 2002; Bantjes et al., 2018; Beksinska et al., 2021; Kinyanda et al., 2012). The studies were from a total sample of 3,398 individuals (overall sample). Out of these, 907 individuals reported experiencing food insecurity and 513 reported unspecified suicidal behaviors. A total of 167 reported having both unspecified suicidal behaviors and food insecurity. The studies were published between 2002 (Alaimo et al., 2002) and 2021 (Beksinska et al., 2021) and the prevalence of unspecified suicide behavior ranged between 1.6% (Kinyanda et al., 2012) and 6.9% (Alaimo et al., 2002). The pooled prevalence of unspecified suicidal behavior was 4.6% (95% CI: 2.8-6.4; $I^2 = 85.5\%$, $p < 0.001$) (**Fig 5**).

Fig. 5: Forest plot for the prevalence of unspecified suicide behaviors among individuals with food insecurity



Random-effects REML model

Heterogeneity source identification tests

There was significant heterogeneity ($I^2 = 85.55\%$) among the included studies. In addition, only two studies were within the funnel plot and there was asymmetry – most studies to the right (**Supplementary Fig. 7**). The Egger's test indicated no small sample size study effect ($\beta = 6.62$, $SE = 3.956$, $p = 0.0543$). However, based on trim and fill, there were no missing studies to be imputed. The leave-one-out meta-analysis indicated that the pooled prevalence was not significantly affected by the removal of any of the studies (**Supplementary Fig. 8**).

Subgroup analysis

In subgroup analysis, there was a significant difference in the prevalence of unspecified suicidal behaviors in the following aspects: continent, countries' income status, and study population (**Table 3**).

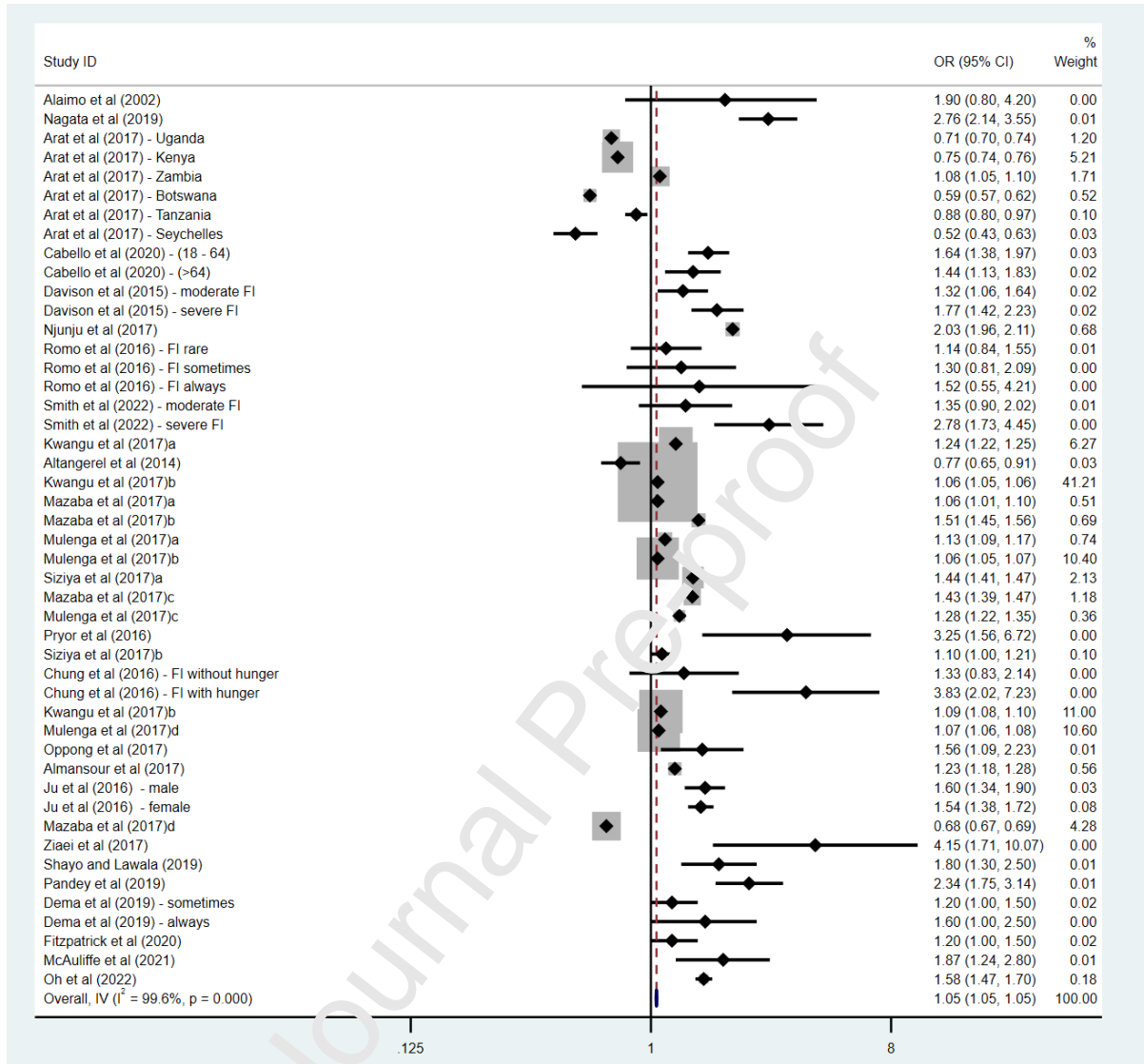
Relationship between suicidal behavior and food insecurity

Some odds ratios were controlled for at least one of the following: demographics (e.g., age, gender, metropolitan region, race-ethnicity, family income, family head education, family head employment status, family head marital status, grade, location and living condition, country, indigenous, LGBT2Q, parent/guardian living with children under 18 years, disability), (ii) mental wellness and well-being (e.g., depression, anxiety or panic disorder, trouble falling asleep in the past four weeks, trouble staying asleep in the past four weeks, common mental disorder, exposure to violence, physical illness, negative affect, mood disorder, ADHD, substance use, comorbid mental conditions, suicide connection with friend or family, impact of event scale, prior mental health, religious social capacity, community connectedness, optimism, and COVID-19 pandemic-related financial worry), (iii) health-related factors (e.g., smoking status, alcohol use, substance use, current cigarette use, ever use of drugs, ever use of marijuana, trouble arising from alcohol use, current cannabis use, ever use of amphetamines, soft drink intake, poor access to health care, and levels of satisfaction with both health and life, and fast food intake), and economic and financial status (e.g. family in debt, personal income, employment, household income, receipt of basic livelihood aid, wealth, financial distress, being dissatisfied with income, having experienced being fired before, and the duration of the longest held job) For details see **Table 1**. The adjusted factors varied across studies but almost all studies adjusted for gender and age.

Suicide ideation

A total of 31 studies reported the relationship between experiencing food insecurity and

suicide ideation (Alaimo et al., 2002; Almansour and Siziya, 2017; Altangerel et al., 2014; Arat, 2017; Cabello et al., 2020; Chung et al., 2016; Davison et al., 2015; Dema et al., 2019; Fitzpatrick and Spialek, 2020; Ju et al., 2016; Kwangu et al., 2017a, b; Kwangu et al., 2017c; Mazaba et al., 2017a; Mazaba et al., 2017b; Mazaba et al., 2017c; Mazaba et al., 2017d; McAuliffe et al., 2021; Mulenga et al., 2017a; Mulenga et al., 2017b; Mulenga et al., 2017c; Mulenga et al., 2017d; Nagata et al., 2019; Njunju et al., 2017; Oh et al., 2022; Oppong Asante et al., 2017; Pandey et al., 2019; Pryor et al., 2016; Romo et al., 2016; Shayo and Lawala, 2019; Siziya et al., 2017a; Siziya et al., 2017b; Smith et al., 2022; Ziaei et al., 2017). The studies were from a total sample of 362,362 individuals (overall sample). Out of these, 67,615 individuals reported food insecurity. The odds between suicide ideation and experiencing food insecurity ranged between 0.52 (Arat, 2017) and 4.15 (Ziaei et al., 2017). Using the common-effect inverse variance model of meta-analysis, the pooled odds ratio between experiencing food insecurity and suicide ideation was 1.049 (95% CI: 1.046-1.052; $I^2 = 99.6\%$, $p < 0.001$) (Fig 6).

Fig. 6: Forest plot for odds ratio between food insecurity and suicide ideation

Subgroup analysis

Based on subgroup analysis, the heterogeneity of the odds ratio between those experiencing food insecurity and suicide ideation was significant in the following subgroups: (i) study design: with cohort studies having 2.5 times higher odds than cross-sectional studies; (ii) country income status: besides LICs where the likelihood of suicide ideation among individuals experiencing food insecurity reduced by approximately 10%, the rest of the countries' economic groups had increased likelihood for suicide ideation among individuals

with food insecurity, with the highest being in HICs; (iii) continent: the likelihood of suicide ideation among individuals experiencing food insecurity increased in almost all continents except in Africa. Europe had the highest increased followed by North America, South America, Asia, and least in Oceania; (iv) study group: all groups had a significant relationship of increasing the likelihood and the odds were highest among the general population; (v) period of food insecurity assessed: apart from past month history of experiencing food insecurity, the rest of the period was associated with suicide ideation among individuals experiencing food insecurity, with 'past week' having the highest likelihood of increasing suicide ideation among individuals experiencing food insecurity; (vi) the duration of suicidal behavior assessed: only the past two weeks and past 12 months were related to a significant increase in the odds of suicide ideation and food insecurity; and (vii) the use of validated tools for assessing food insecurity was associated with having a higher likelihood of suicide ideation (**Table 4**).

Sensitivity analysis

Considering the unadjusted odds ratios for the relationship between experiencing food insecurity and suicide ideations (**Supplementary Table 3**), the pooled odds ratio between suicidal ideations and experiencing food insecurity was 1.273 (95% CI: 1.269 -1.277; $I^2 = 99.8\%$, $p < 0.001$) (**Supplementary Fig 9**). Therefore, controlling for the various variables led to a 21.35% decrease in the strength of the relationship.

Table 4: Subgroup analysis for the relationship between suicide behavior and food insecurity

Variable	Sub-groups	Suicide ideation			Suicide plans			Suicide attempts			Unspecified suicide behavior		
		Degree of freedom	Pooled OR (95% Confidence interval)	Test of difference Q (p-value)	Degree of freedom	Pooled OR (95% Confidence interval)	Test of difference Q (p-value)	Degree of freedom	Pooled OR (95% Confidence interval)	Test of difference Q (p-value)	Degree of freedom	Pooled OR (95% Confidence interval)	Test of difference Q (p-value)
Study design	Cohort	0	3,250 (1.569 – 6.745) *	9.21 (0.002)	0	N/A	N/A	1	1.583 (0.935 – 2.679)	12.01 (0.001)	-	-	N/A
	Cross-sectional	45	1.049 (1.046 – 1.052) *		11	1.480 (1.465 – 1.496) *		22	0.622 (0.617 – 0.626) *		6	1.127 (1.049 – 1.211) *	
Country income status	High-income countries	14	1.411 (1.380 – 1.442) *	1090.87 (<0.001)	1	1.665 (1.525 – 1.819) *	765.82 (<0.001)	5	1.125 (0.984 – 1.285)	1137.68 (<0.001)	-	-	10.12 (0.006)
	Upper middle-income countries	6	1.095 (1.086 – 1.104)		3	1.731 (11.660 – 1.804)		2	0.574 (0.549 – 0.600)		2	1.118 (1.035 – 1.207)	

			*			*			*			*	
	Lower middle-income countries	18	1.039 (1.036 - 1.043) *		3	1.667 (1.642 - 1.691) *		9	0.585 (0.580 - 0.590) *		1	1.027 (0.817 - 1.292)	
	Low-income countries	1	0.909 (0.893 - 0.925) *		1	1.237 (1.216 - 1.257) *		1	0.809 (0.794 - 0.823) *		1	2.468 (1.497 - 4.068) *	
Continent	Africa	10	0.987 (0.982 - 0.992) *	1662.11 (<0.001)	6	1.483 (1.467 - 1.499) *	57.59 (<0.001)	2	0.619 (0.614 - 0.623) *	259.30 (<0.001)	6	1.127 (1.049 - 1.211) *	N/A
	Asia	16	1.065 (1.061 - 1.069) *		0	0.720 (0.595 - 0.872) *		4	1.196 (1.032 - 1.386) *		-	-	
	Europe	0	0.750 (1.569 - 6.745) *		-	-		-	-		-	-	
	North America	6	1.590 (1.497 - 1.688)		0	1.600 (1.448 - 1.768)		2	2.221 (1.824 - 2.705)		-	-	

			*			*			*				
	South America	4	1.414 (1.387 - 1.442) *		2	1.356 (1.110 - 1.656) *		1	1.158 (0.731 - 1.835)		-	-	
	Oceania	1	1.067 (1.026 - 1.109) *		-	-		1	1.392 (0.926 - 1.993)		-	-	
Study population	Adolescents still in school	31	1.047 (1.044 - 1.051) *	319.22 (<0.001)	10	1.479 (1.464 - 1.495)	2.36 (0.125)	17	0.620 (0.615 - 0.625) *	273.40 (<0.001)	1	1.130 (0.893 - 1.429)	7.86 (0.164)
	Males	-	-		-	-		-	-		0	1.099 (0.960 - 1.258)	
	Older persons	3	1.575 (1.571 - 1.882) *		-	-		1	3.538 (2.186 - 5.727) *		-	-	
	General population	8	1.725 (1.574 - 1.890) *		-	-		2	1.940 (1.512 - 2.489) *		-	-	

	Females	-	-			-		0	2.020 (0.499 - 8.173)		0	1.170 (0.671 - 2.040)	
	College students	0	1.580 (1.469 - 1.699) *		0	1.600 (1.448 - 1.768)		0	2.270 (1.832 - 2.813) *		-	-	
	HIV patients'	-	-		-	-		-			0	2.260 (1.058 - 4.829)	
	Hurricane Harvey survivors	0	1.200 (0.980 - 1.470) *		-	-		-	-		-	-	
	Pregnant women	-	-		-	-		-	-		0	5.340 (1.262 - 22.601)	
Meth od of assess ing food insecu rity	Self-report	36	1.049 (1.046 - 1.052) *	39.60 (<0.001) -	8	1.481 (1.465 - 1.496)	0.74 (0.38 9)	21	0.621 (0.617 - 0.626) *	70.77 (<0.001)	3	1.196 (0.971 - 1.473)	0.35 (0.55 2)
	Validated tools	9	1.448 (1.310)		2	1.356 (1.110)		0	2.400 (1.723)		2	1.118 (1.035)	

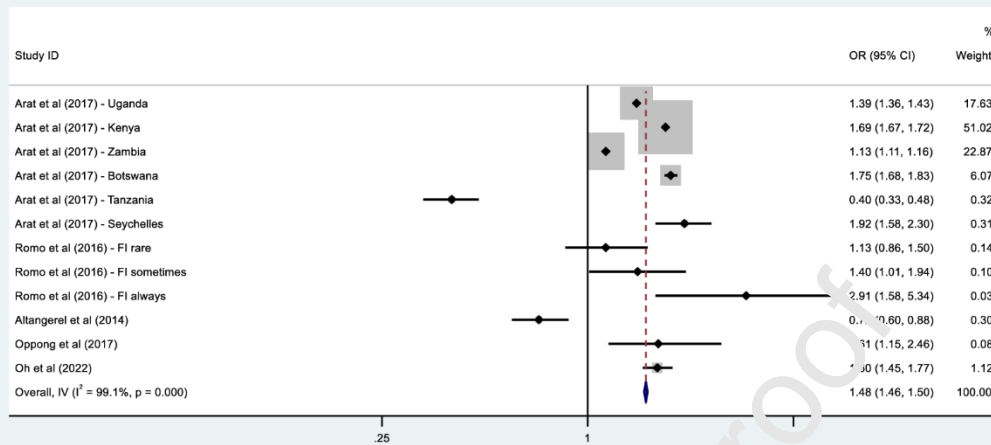
			- 1.601) *			- 1.656)			- 3.344) *			- 1.207)	
	Record review	-	-		-	-		1	1.158 (0.731 - 1.835)		-	-	
Period of food insecurity assessed	Current/ present	0	1.900 (0.829 - 4.353)	3218.07 (<0.001)	-	-	2.41 (0.12 1)	0	5.000 (1.705 11.653) *	338.46 (<0.001)	-	-	4.50 (0.21 2)
	Past week	0	1.870 (1.244 - 2.810) *		-	-			-		0	1.170 (0.671 - 2.040)	
	Past month	11	0.791 (0.783 - 0.799) *		8	1.482 (1.467 - 1.498)		10	0.619 (0.614 - 0.624) *		1	1.124 (0.984 - 1.284)	
	Past 6 months	6	-		-	-		0	2.020 (0.499 - 8.173)		0	5.340 (1.262 - 22.601)	
	Past 12 months	12	32 1.078 (1.075 -)		1	1.601 (1.453 -)		10	1.865 (1.653 -)		2	1.121 (1.028 -)	

			1.082) *			1.763)			2.103) *			1.223)	
Durat	Past 2	1	1.876	9.70	-	-	N/A	0	5.000	14.44	-	-	0
ion of	weeks		(1.301	(0.00					(1.706	(<0.0			(0.96
suicid			-	2)					-	01)			8)
e			2.704)						14.653				
behav)*				
ior	Past	-	-		-	-		-	-		2	1.129	
assess	month											(1.029	
ed												-	
												1.237)	
	Past 12	45	1.049		11	1.480		23	0.622		3	1.125	
	months		(1.046			(1.465			(0.617			(1.002	
			-			-			-			-	
			1.052)			1.496)			0.626)			1.263)	
			*						*				

Suicide plans

A total of five studies reported the relationship between experiencing food insecurity and suicide plans (Altangerel et al., 2014; Arat, 2017; Oh et al., 2022; Oppong Asante et al., 2017; Romo et al., 2016). The studies were from a total sample of 124,046 individuals (overall sample). Out of these, 36,018 individuals reported food insecurity. The odds between suicide plans and food insecurity ranged between 0.4 (Arat, 2017) and 2.91 (Romo et al., 2016). Using the common-effect inverse-variance model of meta-analysis, the pooled odds ratio between experiencing food insecurity and suicide plans was 1.480 (95% CI: 1.465-1.496; $I^2 = 99.1\%$, $p < 0.001$) (Fig 7).

Fig. 7: Forest plot for odds ratio between suicide plan and food insecurity



Subgroup analysis

The countries' income status and continent significantly contributed to the heterogeneity of the pooled odds ratio. The increase in the likelihood of suicide plans among individuals experiencing food insecurity was lowest among LICs. The likelihood of suicide plans among individuals experiencing food insecurity was reduced in Asia by 28%. However, the likelihood increased in the rest of the continents with North America having the highest odds followed by Africa, then South America (**Table 4**).

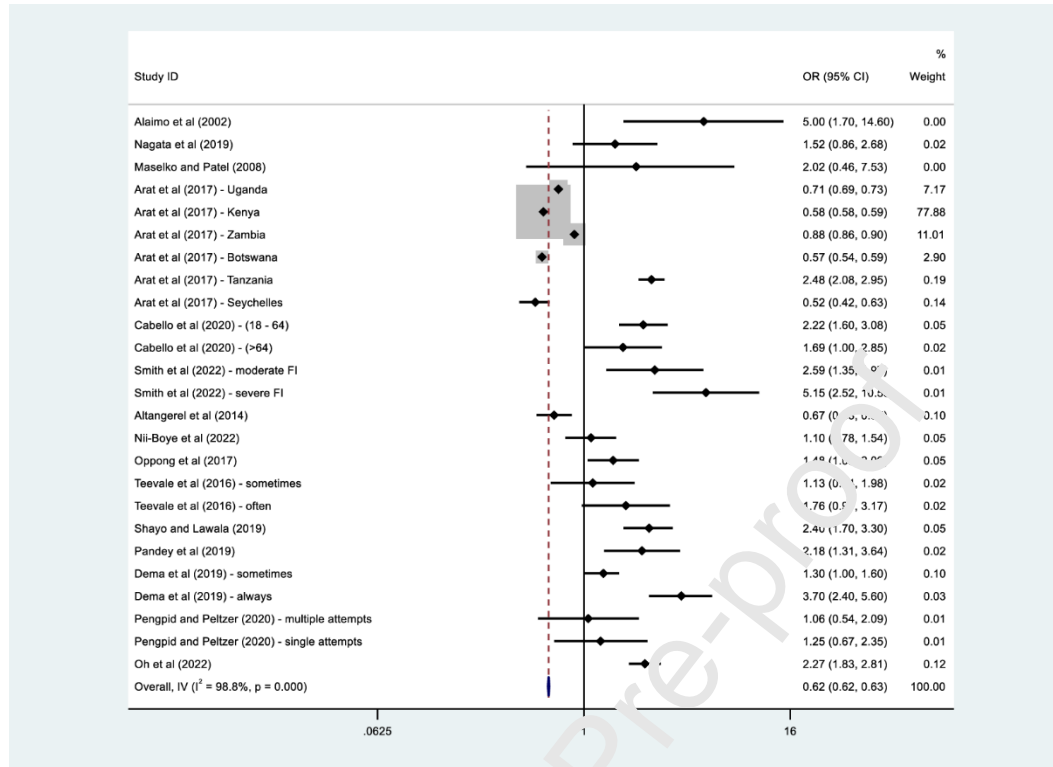
Sensitivity analysis

Considering the unadjusted odds ratios for suicide plans relationship with food insecurity (**Supplementary Table 3**), the pooled odds ratio between suicidal plans and experiencing food insecurity was 1.702 (95% CI: 1.508 - 1.921; $I^2 = 55.6\%$, $p < 0.001$) (**Supplementary Fig**

10). Therefore, controlling for the various variables led to a 15% decrease in the strength of the relationship.

Suicide attempts

A total of 15 studies reported the relationship between experiencing food insecurity and suicide plans (Alaimo et al., 2002; Altangerel et al., 2014; Arat, 2017; Cabello et al., 2020; Dema et al., 2019; Maselko and Patel, 2008; Nagata et al., 2019; Nii-Boye Quarshie and Andoh-Arthur, 2022; Oh et al., 2022; Oppong Asante et al., 2017; Pandey et al., 2019; Pengpid and Peltzer, 2020; Shayo and Lawala, 2019; Smith et al., 2022; Teevale et al., 2016). The studies were from a total sample of 246,603 individuals (overall sample), and out of these, 51,669 individuals reported food insecurity. The odds between suicide attempts and experiencing food insecurity ranged between 0.52 (Arat, 2017) and 5.15 (Smith et al., 2022). Using the common-effect inverse-variance model of meta-analysis, the pooled odds ratio between food insecurity and suicide attempt was 0.622 (95% CI: 0.617-0.627; $I^2 = 98.8\%$, $p < 0.001$) (**Fig 8**).

Fig. 8: Forest plot for odds ratio between suicide attempt and food insecurity

Subgroup analysis

All examined subgroups were statistically responsible for the heterogeneity of the study findings showing the relationship between suicide attempts and food insecurity. For study design, only cross-sectional studies showed a significant relationship, and it reduced the likelihood of suicide attempts among individuals experiencing food insecurity. Apart from studies from HICs, the rest of the relationship between the country's income status significantly reduced the likelihood of suicide attempts among individuals experiencing food insecurity. For continents, the likelihood of suicide attempts among individuals experiencing food insecurity was statistically significantly reduced in the African continent. However, the odds significantly increased in both Asia and North America, with North America having the highest likelihood of suicide attempts among individuals experiencing

food insecurity. In relation to the study group, older individuals had the highest odds of having suicide attempts, followed by college students, and the general population. However, being an adolescent reduced the likelihood of suicide attempts among individuals experiencing food insecurity. The use of validated tools to assess food insecurity showed a significant increase in the odds of suicide attempts. The increase was lower when food insecurity was captured from participants medical records, but self-report measures reduced the odds of suicide attempts by approximately 38% (**Table 4**).

Sensitivity analysis

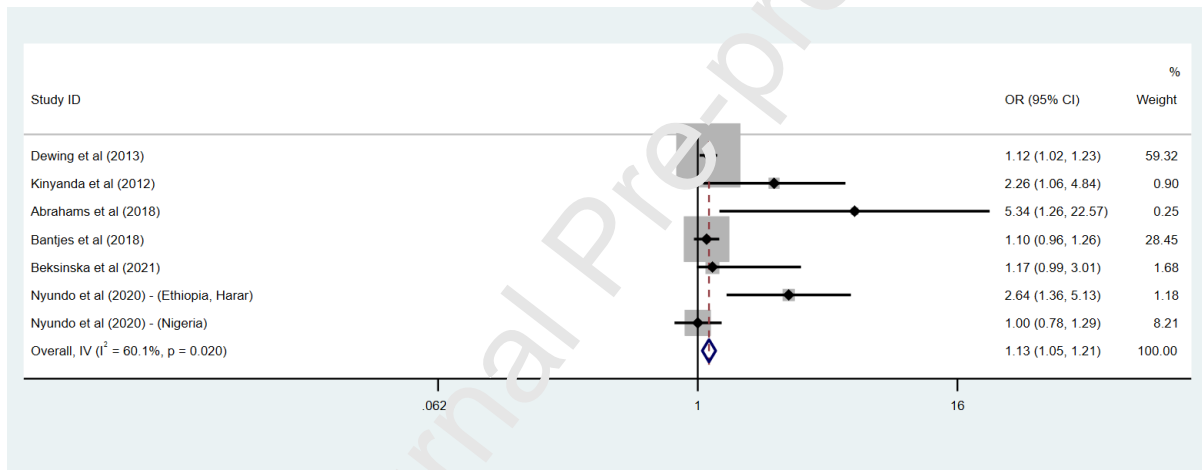
Considering the unadjusted odds ratios for suicide attempts relationship with food insecurity (**Supplementary Table 3**), the pooled odds ratio between suicidal attempts and experiencing food insecurity was 0.616 (95% CI: 0.515 – 0.736; $I^2 = 97.4\%$, $p < 0.001$) (**Supplementary Fig 11**). Therefore, controlling for the various variables led to a 0.96% increase in the strength of the relationship.

Unspecified suicidal behavior

A total of six studies reported the relationship between food insecurity and unspecified suicidal behavior (Abrahams et al., 2018; Bantjes et al., 2018; Beksinska et al., 2021; Dewing et al., 2013; Kinyanda et al., 2012; Nyundo et al., 2020). All the studies were conducted among individuals in Africa. The studies were from a total sample of 4,702 individuals (overall sample). Out of these, 1,090 individuals reported food insecurity. The odds between unspecified suicidal behavior and food insecurity ranged between 1.0 (Nyundo et al., 2020) and 5.34 (Abrahams et al., 2018), whereas a significant increase in

suicidal behaviors with food insecurity was reported among four studies (Abrahams et al., 2018; Dewing et al., 2013; Kinyanda et al., 2012; Nyundo et al., 2020). Using the common-effect inverse-variance model of meta-analysis, the pooled odds ratio between experiencing food insecurity and unspecified suicide behavior was 1.127 (95% CI: 1.049-1.211; $I^2 = 60.1\%$, $p=0.001$) (Fig 9).

Fig. 9: Forest plot for odds ratio between unspecified suicide behavior and food insecurity



Subgroup analysis

Apart from the country's income level, the rest of the examined subgroups were not statistically responsible for the heterogeneity observed in the study findings, showing the relationship between unspecified suicide behavior and food insecurity. The odds between food insecurity and unspecified suicidal behavior were significant for UMICs and LICs. However, the likelihood of having unspecified suicidal behavior increased more in LICs compared to UMICs. (Table 4).

Sensitivity analysis

Considering unadjusted odds ratios for unspecified suicide behavior's relationship with food insecurity (**Supplementary Table 3**), the pooled odds ratio between unspecified suicide behavior and experiencing food insecurity was 3.573 (95% CI: 2.960 – 4.312; $I^2 = 84.4\%$, $p < 0.001$) (**Supplementary Fig 12**).

Discussion

To the best of our knowledge, this is the first systematic and meta-analytic review of the prevalence of suicidal behaviors among individuals with food insecurity globally. The review also highlights the magnitude of the association between suicidal behaviors and experiencing food insecurity. The pooled prevalence estimate was 22.4% for suicide ideation, 18.1% for suicide plans, 17.2% for suicide attempts, and 4.6% for unspecified suicidal behavior. There were high levels of heterogeneity across the included studies attributed to various assessed variables i.e., countries' income level, continent, study population (except for suicide plans), method of assessing food insecurity for suicide attempts, period of food insecurity assessed for suicide ideation and suicide attempts, overall sample size and the number of males for suicide ideation, and the number of females for suicide attempts. The results also showed a positive relationship between experiencing food insecurity and suicide ideation, suicide plans, and unspecified suicide behaviors. However, a negative relationship was found between food insecurity and suicide attempts. The continent where the study was conducted was the common cause of heterogeneity of the differences in the odds of the relationships between experiencing food insecurity and suicidal behaviors.

The association and the prevalence of suicidal ideation among individuals experiencing food insecurity were higher among studies done in HICs especially in North America as compared to other continents. As stated by other reviews in regard to mental health among individuals experiencing food insecurity, this could be due to the disproportionately high number of studies done among HICs (Pourmotabbed et al., 2020b), and further research is needed to give a true reflection of the pooled value in other economies. In addition, it may be because many individuals in HICs are not used to experiencing food insecurity and this uncommon experience in many individuals' lives as compared to other parts of the world, particularly in LICs can easily lead to some individuals experiencing suicidal ideation. In many HICs, experiencing food insecurity may result from overwhelming poverty and inability to afford basic standards of living. Also, many HICs have a large proportion of individuals considered minority groups such as indigenous populations, immigrants, and minority races, who experience high levels of poverty and mental health challenges, are socially isolated, and face systemic discrimination/racism leading to many experiencing both food insecurity and suicide ideation (Odoms-Young and Bruce, 2018). The concept of food insecurity in HICs is not clearly understood and believed to be more due to poverty rather than lack of food availability (Odoms-Young and Bruce, 2018). Future studies are needed to explore how various social factors influence the burden of suicidal behaviors among individuals experiencing/living with food insecurity (e.g., the inequity in the society of riches, forced economic choices on how to use limited resources, increased comorbid mental illness among those who have low income, heightened levels of drug use as form of coping or escape, or lack of resources).

Despite a higher pooled prevalence of suicidal ideation among individuals experiencing food insecurity in HICs, they experienced the lowest levels of suicide attempts. This may be because of improved support services (e.g., emergency phone lines and counsellors) and better care programs for individuals who experience mental health challenges such as suicide ideation and depression, and severe food insecurity. However, in many LICs, especially in rural parts of Africa, food is often home grown and the solution to food insecurity often relies on the individual's farming output which may be affected by climate change, insurgencies, poor-quality plants, and plant pests and diseases. The scenario is quite different in HICs where food availability may mainly depend on the ability to afford food. Such differences in dimensions of food insecurity make individuals from LICs likely to have no alternative to experiencing severe food insecurity, and suicide may be an option if they fail to cope. Due to the growing hardship experienced in the production of food in LICs resulting from climate change, suicide attempts and the associated complications of suicide may worsen in Africa and other countries that depend on subsistent farming methods. With the reduction in global food production, suicide may increase even in countries where individuals can afford to buy food (HICs).

Suicidal ideation was more frequently reported among those who reported a 12-month history of experiencing food insecurity, showing the relationship between chronic suffering and the experience of suicidal ideation. Disproportionally, most studies reporting this chronic suffering were also among adolescents still in school who have been reported to have higher levels of suicidal behavior (Evans et al., 2017; Geoffroy et al., 2022). With this population (i.e., adolescents) facing the worst complication of the growing burden of food

insecurity mainly because of climate change, the prevalence of suicidal behavior in the general population may continuously increase; which is currently a substantial burden to the mental health system and leading to the loss of a productive generation through death by suicide or loss of productivity due to suicidal behavior burden. Intervention to reduce food insecurity especially among the youths, adolescents, children, and students should be designed to help reduce suicidal behavior and mental health burden among this population group globally. The potential solutions to reduce food insecurity reported by previous researchers include: food donations for students, building pay-what-you-can restaurant at schools, and government grants to provide food for students (Pitts and Brothers, 2020). Pitts and Brothers, 2022, reported that students are one of the main group of individuals affected by food insecurity, and this affects their educational success, leads to more school dropouts, and increases involvement in criminal activities such as robbery (Pitts and Brothers, 2020). These complications of food insecurity might destroy students' social structure and protective factors, making the risk of suicidal behaviors and other mental health problems more prevalent among students.

Based on the current meta-regression, the prevalence of suicide ideation increased with an increase in the overall sample size and the total number of male participants in the sample. This may indicate that the more individuals sampled, the more accurately the true burden of suicide ideation is determined among the population. In addition, more males may be included in the study who have been found to have higher suicide ideation related to food insecurity. The male gender has traditionally had the role of looking for food to feed their families (i.e. '*providers*') and in a situation where food insecurity is present, they feel like

failures, and many may start to have thoughts of suicide. However, increased numbers of females was associated with a lower number of suicide attempts among individuals experiencing food insecurity. A finding contradictory to previous research with women having more suicide attempts (Bommersbach et al., 2022). The high burden of parasuicide (suicide attempts) are commonly related (among others) to relational problems, psychosocial problems, impulsivity, borderline personality traits, and food insecurity may rarely be involved. Therefore, there is the possibility that suicide attempts among individuals experiencing food insecurity may contribute minimally to the pooled effect. It should also be noted that, no matter the gender, with growing female emancipation and couples having to share roles to manage the provision of food to the family, the stress involved in providing food and fighting food insecurity may lead to an increase in suicidal behavior in both genders.

Strengths and limitations

The major strength of the present systematic review and meta-analysis of observational studies is that the included studies had less bias, sources of inconsistency, the observed heterogeneities were explained, and the findings obtained concurred highly with literature findings. Taken together, the evidence of this review is considered sufficient and can be used to recommend policy and action plans for practice (see **Table 5**). Despite most of the included studies being of good quality based on the JBI tools (Aromataris, 2021; Joanna Briggs Institute, 2017), there were high levels of heterogeneity with the pooled prevalence obtained. However, this was explained by some of the variables examined in the present study. The pooled estimates within the past 12 months included several studies with a

shorter timeframe (e.g., past two weeks or past month), impeding greater precision. A similar limitation should be considered for food insecurity. This lack of precision in the pooled estimates was illustrated by the subgroup analysis that showed the duration of food insecurity as a significant cause of heterogeneity in the study findings on the prevalence of suicidal ideation and suicide attempts. However, the period of suicide behaviors assessed did not affect the overall pooled prevalence. Data were combined across different age groups despite substantial differences relating to suicidal behaviors known to exist across the study groups. Therefore, it is unsurprising that significant heterogeneity was observed with the study groups.

Although the present study sought to determine the relationship between experiencing food insecurity and suicidal behaviors, most included studies were cross-sectional, and causality between these variables cannot be inferred. Moreover, despite having adjusted odds ratios included in the results, the various individual studies controlled for varying factors causing significant differences in the results. These pooled relationships with adjusted values were lower than those from the unadjusted values, signifying the influence of confounding variables. In addition, many studies did not control for commonly known factors associated with suicidal behaviors such as depression and other mental health disorders which are strongly associated with suicide based on psychological autopsy (Favril et al., 2022). The association between suicidal behaviors and food insecurity was weak, which might signify the other factors being involved in causing suicide behaviors.

Another constraint with the present study is the non-representativeness of all world regions.

In spite the global rise of food insecurity, few studies have been conducted in some parts of the world such as Europe. To show clear relationships between suicide behaviors and food insecurity, large comparative studies assessing the various factors such as mental health symptoms and physical illnesses related to food insecurity are needed to further this understanding. Another limitation in the present study was that the authors could not clearly identify any reasons for the differences in the relationships between food insecurity and suicidal behaviors among HIC and lower income countries. A comparison of the regions using both qualitative and quantitative methodology could yield a better understanding in the impact of food insecurity/type of food insecurity on suicidal behaviors. Additionally, an assessment tool to better capture food insecurity based on lack of access to good quality food could be developed to accurately capture this type of food insecurity.

Table 5: Recommendations based on study findings

Education, mental health training, and public health practice
<ul style="list-style-type: none"> Information about the health and social impacts of food insecurity should be integrated to the training of mental health practitioner. Screen for suicide among individuals affected by food insecurity is indicated. The training should include the management of suicidal behaviors and incorporate approaches to assist or advocate for individuals facing food insecurity Preventive mental health services and resources are needed to promote resilience and bolster support among vulnerable populations, especially in contexts that are prone f to food insecurity (e.g., conflict, natural disaster and poverty)
Community and other stakeholders

- There should be screening for suicidal behaviors among individuals who use food insecurity relief programs.

Research

- Researchers should use validated tools to assess both food insecurity, suicidal behaviors to reduce the limitation of report bias and promote well powered future quality reviews and meta-analysis
- There is need for future studies, exploring risk and other associated factors to inform early identification and development of time-efficient screening tools. More studies are needed especially in contexts with scanty report to allow a representative global overview

Conclusions

For those burdened with food insecurity, suicidal behavior is an issue of increasing concern worldwide, and suicidal behavior and its associated complications may be greater in HICs. Consequently, initiatives to reduce food insecurity (e.g., improving farm yields, encouraging food donation, and reducing food waste) would likely be beneficial for managing suicidal behaviors and promote mental health wellbeing in contexts and population with food insecurity. Multi-pronged action plan and collaboration among relevant stakeholders are needed to manage the high burden of mental health complications and suicidal behavior among food insecure populations.

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Authors statement***Contributors***

Conception and design of the study: MMK, MAM, FAM, ATO, and RA. Data collection (MMK, RA, BF, IC, and FAM) and its coordination by SP. Supervision: MDG, SH, and GC. Formal analysis and data cleaning: MMK, FAM, and ATO. Initial draft: MMK and FAM. Review of the manuscript: all authors. Visualization: MAM and MMK. Final editing and critical appraisal of the whole manuscript: MDG. All the authors approved the final version of the manuscript.

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This study reviews secondary data, and therefore, no formal ethical approval is required.

Availability of data and materials

All data generated or analyzed during this study are included in this published paper.

Conflict of interests

The authors have no conflict of interest or financial and personal relationships with other individuals or organizations that could bias the findings.

Highlights

1. The prevalence of suicidal behaviors, including suicide ideation, plans, attempts, and unspecified suicidal behaviors, is high among individuals experiencing food insecurity.
2. The prevalence of suicidal behaviors was higher in high-income countries compared to other countries, and the rates in North America were particularly higher compared to other continents.
3. With the exception of suicide attempts, all other types of suicidal behaviors had a positive significant relationship with food insecurity.
4. Initiatives to reduce food insecurity could be beneficial for mental wellbeing and to mitigate the risk of suicidal behaviors among populations experiencing food insecurity. In addition, there is a need to screen for suicide among individuals experiencing food insecurity for early management, support, and intervention.