

Title: Association between food insecurity and fall-related injury among adults aged ≥ 65 years in low- and middle-income countries: the role of mental health conditions

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ABSTRACT

Purpose: We investigated the association between food insecurity and fall-related injury among older adults from six low- and middle-income countries (LMICs), and the extent to which this association is mediated by mental health.

Methods: Cross-sectional, community-based, nationally representative data from the WHO Study on global AGEing and adult health (SAGE) were analyzed. Past 12-month food insecurity was assessed with two questions on frequency of eating less and hunger due to lack of food. Fall-related injury referred to those that occurred in the past 12 months. Multivariable logistic regression analysis and mediation analysis were conducted to assess associations.

Results: Data on 14,585 adults aged ≥ 65 years [mean (SD) age 72.5 (11.5) years; 54.9% females] were analyzed. After adjustment for potential confounders, severe food insecurity (versus no food insecurity) was associated with 1.95 (95%CI=1.11-3.41) times higher odds for fall-related injury. Moderate food insecurity was not significantly associated with fall-related injury (OR=1.34; 95%CI=0.81-2.25). The mediation analysis showed that 37.3%, 21.8%, 17.7%, and 14.0% of the association between severe food insecurity and fall-related injury was explained by anxiety, sleep problems, depression, and cognition, respectively.

Conclusion: Severe food insecurity was associated with higher odds for injurious falls among older adults in LMICs, and a large proportion of this association may be explained by mental health complications. Interventions to improve mental health among those who are food insecure and a strong focus on societal and government efforts to reduce food insecurity may contribute to a decrease in injurious falls.

Key words: Fall-related injury, Older adults, Food insecurity, Low- and middle-income countries

INTRODUCTION

A fall is defined as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level (1). Each year approximately 646,000 individuals die from falls globally, of which over 80% of these deaths occur in low- and middle-income countries (LMICs). Moreover, 37.3 million falls that are severe enough to require medical attention occur each year, and adults ≥ 65 years are likely to suffer from the highest number of fatal falls (1). In addition, falls are associated with a higher risk of loss of independence, autonomy, and confidence (2,3). Given the high prevalence of falls and the detrimental outcomes particularly for older adults, it is important to identify risk factors for falls in this population.

A plethora of risk factors for falls have been identified in older adults and include factors such as balance problems and weakness, poor vision, long term health conditions (e.g., heart disease, hypotension and dementia), and environmental trip and slip hazards (e.g., wet floors and rugs or carpets not properly secured) (4). There is also a large body of literature showing that poor nutrition may also be associated with falls. For example, in one study of 1429 Australian women aged ≥ 70 years, it was found that those with higher total and cruciferous vegetable intake had lower risk for injurious falls (5). Furthermore, in a study of 4450 North America adults (mean age 61.2 years, females = 59.6%), it was found that high dietary protein intake may increase the risk of falls in older people (6). Other studies have identified an association between micronutrient deficiencies and a higher fall risk including for example Vitamin D (7) and Vitamin B12 (8).

Another dietary correlate that may be associated with fall risk is food insecurity. Food insecurity is defined as “limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire food in socially acceptable ways” (9). Food

insecurity often compromises diet quality, as people tend to switch to more affordable but less nutritious food when food is scarce (e.g., high fat and carbohydrates, low vitamins and micronutrients) (10). Food insecurity may lead to higher risk of falls via frailty due to reduction in energy and nutrient intake (11), as frailty is one of the key causes of falls in older adults (12). Moreover, food insecurity is associated with higher risk for mental health complications such as depression, anxiety, sleep problems and cognitive impairment (13-16) and those with mental health complications are also at a greater risk of falling (17-19). Therefore, mental health complications may present as a key mediator in the association between food insecurity and falls.

However, studies on this topic are scarce. In one study consisting of 26,525 US adults, participants who reported food insecurity had 1.69 times higher odds of experiencing a fall in the past year than in those without food insecurity. To the best of our knowledge, no other study exists on the relationship of food insecurity with fall risk. It is clear that more research is needed from other settings such as LMICs where the majority of falls in older adults occur (1), and where the prevalence of food insecurity is high. Thus, the aim of the present study was to investigate the association between food insecurity and fall-related injury in a sample of 14,585 adults aged ≥ 65 years. A further aim was to identify whether mental health complications (i.e., sleep problems, cognition, depression, anxiety) serve as mediators in the relationship between food insecurity and fall-related injury.

METHODS

The survey

Data from the Study on Global Ageing and Adult Health (SAGE) were analyzed. These data are publicly available through <http://www.who.int/healthinfo/sage/en/>. This survey was

undertaken in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and 2010. Based on the World Bank classification at the time of the survey, all these countries were LMICs.

Details of the survey methodology have been published elsewhere (20). Briefly, in order to obtain nationally representative samples, a multistage clustered sampling design method was used. The sample consisted of adults aged ≥ 18 years with oversampling of those aged ≥ 50 years. Trained interviewers conducted face-to-face interviews using a standard questionnaire. Standard translation procedures were undertaken to ensure comparability between countries. The survey response rates were: China 93%; Ghana 81%; India 68%; Mexico 53%; Russia 83%; and South Africa 75%. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Food insecurity (exposure)

Food insecurity was defined with the use of 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 answer 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); and never (coded=5). These items were adapted from similar items 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 previous SAGE studies, 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 meet 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 (15,21).

Fall-related injury (outcome)

The variable on fall-related injury of the SAGE was derived from questions of the WHO guidelines on injuries (22). First, the participant was asked “In the past 12 months, have you had any other event (other than a road traffic accident) where you suffered from bodily injury?” Those who answered affirmatively were prompted to the next question “What was the cause of the injury?” If there were multiple injuries, the respondent was instructed to refer to the most recent injury. If the respondent answered “fall”, then he or she was considered to have had a fall-related injury in the past year.

Control variables

The control variables were selected based on past literature (23,24), and included age, sex, wealth quintiles based on income, education, and disability. Disability was assessed by standard basic activities of daily living (ADL questions) (25-27) which included six questions with the introductory phrase “overall in the last 30 days, how much difficulty did you have” followed by: in washing your whole body?; in getting dressed?; with moving around inside your home?; with eating (including cutting up your food)?; with getting up from lying down?; and with getting to and using the toilet? Answer options were none, mild, moderate, severe, extreme/cannot do. ADL disability was a dichotomous variable where those who answered severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL (28).

Mediators

We also assessed the potential influence of several mental health factors (i.e., sleep problems, cognition, depression, anxiety) which may serve as mediators in the association between food insecurity and falls. These factors were selected based on previous literature suggesting that food insecurity may potentially lead to these mental outcomes, while in turn, these conditions can lead to falls (29-34). Sleep problems were assessed by the question “Overall in the last 30 days, how much of a problem did you have with sleeping, such as falling asleep, waking up frequently during the night or waking up too early in the morning?” with answer options none, mild, moderate, severe, and extreme. Subjective cognitive complaints were assessed with two questions: (a) “Overall in the last 30 days, how much difficulty did you have with concentrating or remembering things?”; and (b) “In the last 30 days, how much difficulty did you have in learning a new task (for example, learning how to get to a new place, learning a new game, learning a new recipe etc.)?” Each item was scored on a five-point scale: none (code=1), mild (code=2), moderate (code=3), severe (code=4), and extreme/cannot do (code=5). Since these answer options were an ordered categorical scale, as in previous studies using datasets with the same survey questions, we conducted factor analysis with polychoric correlations to incorporate the covariance structure of the answers provided for individual questions measuring a similar construct (35-38). The principal component method was used for factor extraction, while factor scores were obtained using the regression scoring method. These factor scores were later converted to scores ranging from 0-100 to create a cognitive function scale with higher values representing worse cognitive function. Questions based on the World Mental Health Survey version of the Composite International Diagnostic Interview (39) were used for the endorsement of past 12-month DSM-IV depression (40) (Details provided in **Table S1** of the Appendix). Individuals who had received treatment for

depression in the past 12 months were also considered to have depression. Anxiety was assessed by the question “Overall in the past 30 days, how much of a problem did you have with worry or anxiety” with response alternatives: none, mild, moderate, severe, and extreme.

Statistical analysis

The statistical analysis was performed with Stata 14.2 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged ≥ 65 years to focus on the older population. Multivariable logistic regression was done with food insecurity as the exposure variable and fall-related injury as the outcome. Furthermore, we assessed the degree to which the association between severe food insecurity and fall-related injury can be explained by four mental health conditions (i.e., sleep problems, cognition, depression, anxiety). The dichotomous variable of severe food insecurity (versus moderate or no food insecurity) was used for this analysis as preliminary analysis showed that the association between food insecurity and fall-related injury is particularly strong for severe food insecurity. We used the *khb* (Karlson Holm Breen) command in Stata for this purpose. This method can be applied in logistic regression models and decomposes the total effect (i.e., unadjusted for the mediator) of a variable into direct (i.e., the effect of severe food insecurity on fall-related injury adjusted for the mediator) and indirect effects (i.e., the mediational effect). Using this method, the percentage of the main association explained by the mediator can also be calculated (mediated percentage). The mediated percent is the percent attenuation in the log odds for the association between food insecurity and fall-related injury after the mediator is included in the model. All regression analyses were adjusted for age, sex, wealth, education, disability, and country. Adjustment for country was done by including dummy variables for each country in the model as in previous SAGE publications (41,42). Under 2.9% of the data for the variables in used in the analysis were missing. Complete case analysis was done. The

sample weighting and the complex study design were taken into account in the analyses.

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

A total of 14,585 (China $n=5360$; Ghana $n=1975$; India $n=2441$; Mexico $n=1375$; Russia $n=1950$; and South Africa $n=1484$) adults aged ≥ 65 years constituted the final sample. The prevalence of moderate and severe food insecurity was 6.7% and 5.0%, respectively, while 4.8% of participants experienced a fall-related injury in the past year. The sample characteristics are shown in **Table 1**. The mean (SD) age of the sample was 72.6 (11.5) years and 54.9% were females. **Figure 1** illustrates the prevalence of fall-related injury by food insecurity status. The prevalence of fall-related injury was more than twice higher among those with severe food insecurity compared to those with no food insecurity (9.6% versus 4.4%). **Table 2** shows the association between food insecurity and fall-related injury estimated by multivariable logistic regression. After adjustment for potential confounders (i.e., age, sex, wealth, education, disability, and country), severe food insecurity (versus no food insecurity) was associated with a 1.95 (95%CI=1.11-3.41) times higher odds for fall-related injury. Moderate food insecurity was not significantly associated with fall-related injury (OR=1.34; 95%CI=0.81-2.25). The results of the mediation analysis are shown in **Table 3**. We found that 37.3%, 21.8%, 17.7%, and 14.0% of the association between severe food insecurity and fall-related injury was explained by anxiety, sleep problems, depression, and cognition.

DISCUSSION

In this large sample of older adults from six LMICs, it was found that severe food insecurity (versus no food insecurity) was associated with a 1.95 times higher odds for fall-related injury, but there was no statistically significant association with moderate food insecurity. Importantly, mental health complications explained a large proportion (up to 37.3%) of the association between severe food insecurity and fall-related injury.

Findings from the present study support and add to the only previous study examining this association in one high-income country (i.e., USA) (23). It supports the previous study by confirming that an association exists between food insecurity and falls in a large sample of older adults from LMICs and adds to the existing knowledge by demonstrating that a large proportion of the relationship may be explained by mental health complications.

Food insecurity is likely associated with mental health complications through several mechanisms. First, food insecurity per se may result in mental health complications. For example, not being able to provide sufficient food for one's family is associated with higher levels of stress and anxiety (43). Higher levels of depression, anxiety, and sleep disturbances are subsequently likely to increase levels of cognitive impairment (44). Second, some nutritional deficiencies have been reported to increase risk for mental health problems. Alternatively, mental health complications have been found to influence the individual's ability to obtain and retain employment, particularly for individuals with lower education, and this may have an impact on the family's income and the ability to supply food for the household (13).

In turn, mental health complications can increase risk of injurious falls via several pathways. First, mental health complications can increase one's risk of falling per se via executive dysfunction, increased risk of fear of falling, and changes in gait (31). Moreover, medications to treat mental health complications (e.g., benzodiazepines and selective serotonin reuptake inhibitors) can further lead to an increased risk of falls via, for example, impaired balance, orthostatic changes, movement disorders, and hyponatremia (31).

Next, food insecurity can also lead to falls not only via mental health problems, but also by increasing the risk of malnutrition, sarcopenia, and frailty (45). For example, vitamin D deficiency and low calcium intake have been shown to be associated with fall risk (7). The role of sufficient levels of vitamin D and calcium in falls prevention is complex but a large body of literature suggests that vitamin D may aid in the prevention of falls through the maintenance of muscle integrity (7). Furthermore, low protein intake can lead to sarcopenia in older adults (46), and sarcopenia is also associated with a higher fall risk, through a loss of muscle mass, strength and impaired physical performance (47). Finally, food insecurity has also been found to be associated with frailty (48), likely via malnutrition, and frailty per se is a key risk factor for falls in older adults (49).

The large sample of older adults from six LMICs is a clear strength of the present study. However, findings from this study must be interpreted in light of its limitations. First, the study was cross-sectional in nature and thus it is not known whether food insecurity leads to fall-related injury or whether fall-related injury leads to food insecurity. For example, it is also possible that an injurious fall results in a loss of employment and subsequent food insecurity, particularly in LMICs where physically demanding work such as farming is common. Future research utilizing longitudinal designs are now required. Second, our

measure of food insecurity was based on two questions and did not constitute a comprehensive food insecurity measure. Next, data were self-reported and thus, reporting bias (e.g., recall bias and social desirability bias) may exist. Furthermore, we were unable to conduct country-wise analysis as stable estimates could not be obtained due to the small sample size and low prevalence of severe food insecurity and fall-related injuries in some countries. Future studies should attempt to assess whether the association is context-specific within LMICs. Finally, although we did adjust for levels of wealth in our study, we cannot preclude the possibility that food insecurity may be a marker of other types of material deprivation (e.g., housing conditions, treatment for illness), which may not be reflected in our measure of wealth, and can be related with both mental health problems and falls.

In conclusion, in this large sample of older adults from six LMICs, it was found that severe food insecurity was associated with a higher risk of injurious falls and a large proportion of this association may be explained by mental health complications. Screening for food insecurity and mental health problems among individuals with food insecurity and addressing these problems may help reduce rates of fall in older populations. If causality is confirmed in future longitudinal studies, a strong focus on societal and government efforts to decrease the prevalence of food insecurity may contribute to reducing falls among the older population.

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TABLES AND FIGURES

Table 1 Sample characteristics (overall and by food insecurity status and fall-related injury)

Characteristic		Overall	Food insecurity			Fall-related injury	
			None	Moderate	Severe	No	Yes
Age (years)	Mean (SD)	72.6 (11.5)	72.6 (11.0)	71.9 (12.6)	72.5 (14.9)	72.5 (11.4)	72.9 (10.5)
Sex	Male	45.1	46.1	37.7	37.8	45.7	34.0
	Female	54.9	53.9	62.3	62.2	54.3	66.0
Wealth	Poorest	21.6	19.5	35.3	41.6	21.6	22.9
	Poorer	20.9	20.0	29.3	26.9	20.9	21.9
	Middle	20.4	20.4	22.3	18.6	20.4	20.9
	Richer	17.5	18.8	8.0	7.6	17.5	17.3
Education	Richest	19.5	21.4	5.1	5.3	19.6	17.0
	Primary or less	63.5	62.6	68.4	72.6	62.7	79.8
	Secondary	30.0	30.4	29.4	24.3	30.8	15.9
	Tertiary	6.5	7.0	2.2	3.1	6.6	4.3
Disability	No	88.1	89.5	82.5	70.8	88.5	79.4
	Yes	11.9	10.5	17.5	29.2	11.5	20.6
Sleep problems	None	38.9	40.6	29.7	21.1	39.5	26.6
	Mild	28.9	29.4	27.1	21.9	29.4	18.0
	Moderate	20.0	19.0	23.5	32.9	19.4	29.5
	Severe	11.1	10.1	17.5	20.6	10.4	23.8
	Extreme	1.2	1.0	2.1	3.5	1.1	2.1
Cognition	Mean (SD)	38.6 (49.4)	37.4 (47.5)	45.6 (57.5)	50.6 (59.7)	38.0 (49.3)	50.9 (45.5)
Depression	No	92.9	94.2	85.9	79.6	93.4	82.4
	Yes	7.1	5.8	14.1	20.4	6.6	17.6
Anxiety	None	53.4	56.5	36.8	21.4	54.5	32.1
	Mild	22.5	22.1	24.0	26.9	22.6	18.9
	Moderate	14.4	13.0	20.1	30.4	13.9	24.4
	Severe	8.9	7.7	17.7	18.2	8.1	23.9
	Extreme	0.9	0.7	1.3	3.2	0.9	0.6

Abbreviation: SD Standard deviation

Data are % unless otherwise stated.

Table 2 Association between food insecurity or covariates and fall-related injury (outcome) estimated by multivariable logistic regression

Characteristic		OR	95%CI	P-value
Food insecurity	None	1.00		
	Moderate	1.35	[0.81,2.25]	0.255
	Severe	1.95	[1.11,3.41]	0.019
Age (years)		1.01	[1.00,1.03]	0.145
Sex	Male	1.00		
	Female	1.61	[1.19,2.18]	0.002
Wealth	Poorest	1.00		
	Poorer	1.12	[0.77,1.63]	0.537
	Middle	1.13	[0.73,1.75]	0.587
	Richer	1.13	[0.72,1.78]	0.589
	Richest	1.06	[0.68,1.65]	0.807
Education	Primary or less	1.00		
	Secondary	0.66	[0.46,0.94]	0.022
	Tertiary	0.88	[0.43,1.79]	0.726
Disability	No	1.00		
	Yes	1.66	[1.15,2.39]	0.007

Abbreviation: OR Odds ratio; CI Confidence interval

Model is mutually adjusted for all variables in the Table and country.

Table 3 Mediators in the association between severe food insecurity and fall-related injury

Mediator	Effect	OR [95%CI]	P-value	Mediated %
Sleep problems	Total	1.74 [1.02,2.97]	0.042	21.8
	Direct	1.54 [0.91,2.61]	0.106	
	Indirect	1.13 [1.05,1.21]	0.001	
Cognition	Total	1.75 [1.02,2.99]	0.041	14.0
	Direct	1.62 [0.94,2.77]	0.080	
	Indirect	1.08 [1.02,1.14]	0.006	
Depression	Total	1.66 [0.97,2.84]	0.065	17.7
	Direct	1.52 [0.88,2.6]	0.130	
	Indirect	1.09 [1.03,1.16]	0.005	
Anxiety	Total	1.72 [1.02,2.91]	0.042	37.3
	Direct	1.41 [0.83,2.38]	0.204	
	Indirect	1.23 [1.09,1.37]	<0.001	

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, wealth, education, disability, and country.

The total effect is based on a model which is unadjusted for the mediator. The direct effect is the effect of severe food insecurity on fall-related injury adjusted for the mediator, and the indirect effect is the mediational effect.

The mediated percent is the percent attenuation in the log odds for the association between food insecurity and fall-related injury after the mediator is included in the model.

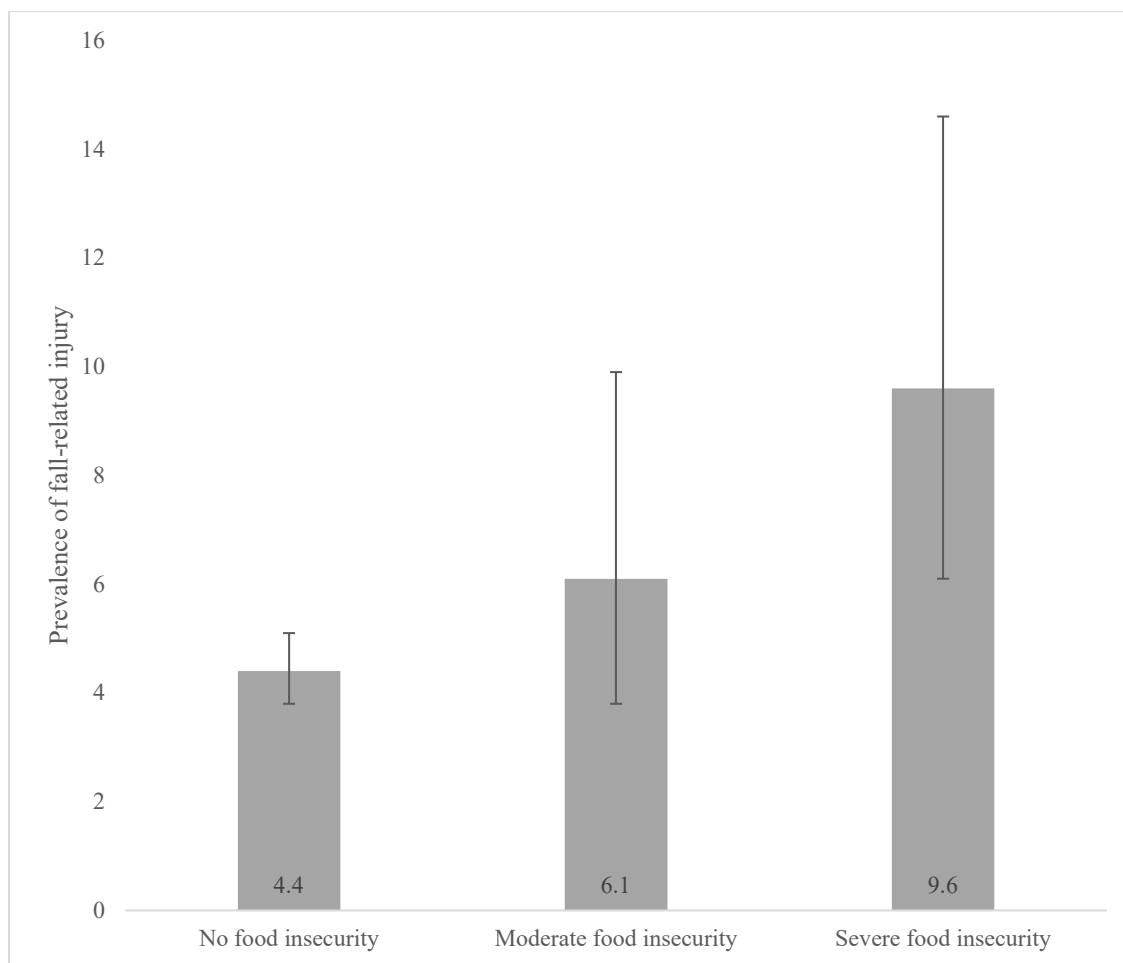


Figure 1 Prevalence of fall-related injury by food insecurity status
Bars denote 95% confidence interval.

APPENDIX

Table S1 Questions and answer options used for endorsement of DSM-IV depression

1. At least one of the two following symptoms in the last 12 months:

- (a) A period, lasting several days, of feeling sad, empty or depressed.
- (b) A period lasting several days with a loss of interest in most things the participant usually enjoys such as personal relationships, work or hobbies/recreation.

AND

2. The period of sadness/loss of interest/low energy lasted for more than two weeks and was most of the day and nearly every day.

AND

3. Five or more of the following symptoms:

- (a) Loss of appetite
 - (b) Insomnia (problems falling asleep or waking up too early)
 - (c) Decreased energy or tiredness all the time
 - (d) Slowing down in moving around or restless/jittery.
 - (e) Negative feelings/loss of confidence or frequent feelings of hopelessness.
 - (f) Slowed thinking or difficulties concentrating (e.g., listening to others, working, watching TV, listening to the radio).
 - (g) Thoughts of death, wishes of own death or suicide attempt.
 - (h) Feelings of sadness, emptiness or depression lasting several days.
 - (i) Anhedonia: loss of interest in things the participant usually enjoys.
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