



Research Paper

Psychosomatic mechanisms linking food insecurity with psychological distress among artisanal miners in Ghana

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ABSTRACT

High levels of food insecurity (FI) and psychological distress (PD) continue to intersect in fragile, under-researched labor settings such as artisanal mining communities in Ghana. While the connection between food deprivation and poor mental health is increasingly acknowledged, the psychosomatic mechanisms that underlie this association remain poorly understood in low-income contexts. This study examines the association between FI and PD among artisanal miners in Ghana and explores the potential mediating role of psychosomatic factors in this association. Data were drawn from a cross-sectional survey of 664 adult miners. Fully adjusted regression models showed that FI was positively associated with higher levels of PD. Miners who were food secure ($\beta = 0.340$, CI = 6.397–8.203) or marginally food secure ($\beta = 0.693$, 95% CI = 12.507–14.377) reported significantly lower levels of PD compared to those who were food insecure. Bootstrapping estimates revealed that work-stress (24.46%), personal stress (~2%), sleep problems (1.30%), physical exhaustion (~1%), and comorbidities (~1%) significantly and partially mediated the FI-PD association. These findings suggest that improving food access and addressing psychosomatic stressors may help mitigate psychological distress in this population.

1. Introduction

In recent years, a growing body of literature has documented the rising prevalence and impact of psychological distress (PD), particularly in low- and middle-income countries (LMICs), where social and economic instability intersects with under-resourced health systems (Narcisse et al., 2021, Peltzer et al., 2012, Tindi et al., 2024). Psychological distress, characterized by symptoms such as anxiety, depression, restlessness, and hopelessness (Tindi et al., 2024, Kessler et al., 2012), has been linked with a wide array of health and social consequences, including suicidal ideation (Dong et al., 2022), substance abuse (Lensch et al., 2021), chronic illness (Hockey et al., 2022), impaired quality of life (Vlake et al., 2021), and reduced work productivity (Viertö et al., 2021). Evidence from LMICs further suggests that PD is disproportionately high among individuals in precarious and informal employment sectors (Méndez Rivero et al., 2021, Silva-Peñaherrera et al., 2022). Artisanal small-scale miners (ASMs), who typically operate outside formal labor protections and face significant occupational,

environmental, and socio-economic risks, represent one such high-risk population. Studies from both Global South and North have reported alarming levels of depression, anxiety, and post-traumatic symptoms among mineworkers, with prevalence ranging from 30%–47%, which is substantially higher than estimates reported for the general population, where prevalence typically ranges from approximately 4%–29% depending on whether clinical diagnoses or symptom-based measures are used (Blanc et al., 2024, Harris et al., 2021, Yong et al., 2020, Nochaiwong et al., 2021). These miners often endure unsafe working conditions, economic insecurity, environmental degradation, and limited access to psychosocial care, factors that cumulatively heighten their susceptibility to psychological harm (Yong et al., 2020). Consequently, identifying modifiable social determinants of psychological distress among mine workers is critical to inform the development of responsive, evidence-based mental health interventions in these vulnerable and overlooked populations.

One key determinant of PD that remains relatively underexplored among artisanal miners is food insecurity (FI), defined as the lack of

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consistent physical or economic access to sufficient, safe, and nutritious food (Gallegos et al., 2023, Gyasi et al., 2020). Food insecurity disproportionately affects LMICs, and is particularly acute among individuals in informal labor sectors with unstable income sources, such as artisanal miners. Recent global estimates suggest that over 2.4 billion people experienced moderate or severe food insecurity in 2022, with the highest burden concentrated in Sub-Saharan Africa (SSA) and South Asia (Otekuurin, 2024). In particular, individuals who are chronically food insecure may experience a constant sense of fear, powerlessness, and social exclusion, all of which contribute to psychological distress (Ciciurkaite and Brown, 2022). Empirical studies have shown that FI is associated with increased risks of depression (Smith et al., 2021), anxiety (Wolfson et al., 2021), and overall psychological distress (Jandaghian-Bidgoli et al., 2024). Recent evidence from Global South also suggests that food insecurity is an independent predictor of poor mental health outcomes across diverse population groups, including youth, women, and informal workers (Gyasi et al., 2020, Jandaghian-Bidgoli et al., 2024). Among ASMs, who typically endure erratic income streams and inadequate social protection, FI may serve as a daily stressor that exacerbates psychological suffering. Indeed, several studies have examined the relationship between food insecurity and psychological distress (Narcisse et al., 2021, Smith et al., 2021, Chang et al., 2021, Owusu-Sarpong et al., 2024, Pourmotabbed et al., 2020). For instance, Gyasi et al. (2020) found that food insecurity is related to higher odds of developing psychological disorders among 1201 Ghanaian older adults. Similarly, Narcisse et al. (2021) found a positive association between FI and depression among 2636 low-income adults aged 18 years and older in the U.S. However, little is known about this association in the context of artisanal miners in SSA, who are uniquely exposed to intersecting vulnerabilities.

Although the exact mechanism linking this association is not known, a constellation of psychosomatic and behavioral pathways has been theorized, including nutritional deficiencies, inflammation, work related stress, personal life stressors, sleep problems, physical exhaustion, and comorbid health conditions (Gyasi et al., 2020, Owusu-Sarpong et al., 2024). These factors can exacerbate work stress, particularly among ASMs, whose informal and hazardous labor conditions are already physically and psychologically taxing (Odonkor and Adams, 2021). Again, FI may intensify personal stress by increasing worries related to household survival, caregiving responsibilities, and future uncertainty (Smith et al., 2021, Myers, 2020). The chronic worry and energy depletion associated with FI may also impair sleep patterns, disrupt rest cycles, and reduce the body's capacity to recover from strain (Nagata et al., 2019). Additionally, limited nutrient intake combined with exhaustive labor can result in severe physical fatigue and reduced immunity, which in turn predispose individuals to chronic illnesses and comorbidities such as hypertension, ulcers, or musculoskeletal disorders. It is possible that the FI-PD link may be mediated by these psychosomatic factors. However, few studies have quantitatively assessed the extent to which these factors mediate the FI-PD link among artisanal miners. Understanding these underlying mechanisms is essential for designing precise, evidence-informed mental health and food policy interventions tailored to vulnerable occupational groups in low-resource settings.

Therefore, this study aims to investigate the association between food insecurity and psychological distress, and the mediating role of work stress, personal stress, sleep problems, physical exhaustion, and comorbidities in this association. It is hypothesized that food insecurity would be positively associated with higher levels of PD, and that, psychosomatic factors would explain a substantial proportion of this association (see Fig. 1).

2. Methods

This community-based cross-sectional survey was conducted in the Obuasi Municipality in the Ashanti Region of Ghana. The municipality

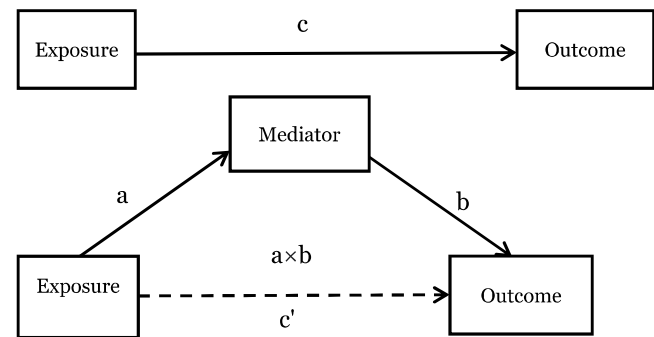


Fig. 1. Mediating framework for the association between food insecurity and psychological distress among ASMs.

a=path coefficient of the effect of exposure on mediator;
 b=path coefficient of the effect of mediator on outcome;
 c'=path coefficient of the direct effect of the exposure on outcome;
 a×b=indirect effect of exposure on outcome; and
 c=total effect of exposure on outcome.

lies approximately 60 km south of Kumasi, covers about 162 km², and has an estimated population of 175,000 (Ghana Statistical Service [GSS], 2013). The municipality hosts a near-equal gender distribution (49.7% males and 50.3% females), with about 61% of residents within the working-age group (15–64 years), indicating a largely economically active population (GSS, 2021). Obuasi experiences a tropical climate, with a rainy season from April to October and a dry season from November to March, and average annual temperatures ranging from 25°C to 32°C (GSS, 2021).

The municipality comprises approximately 32 communities, many of which depend heavily on mining for livelihoods (GSS, 2021). Obuasi has a long history of gold mining and hosts the Obuasi Gold Mine, one of Ghana's largest gold-producing operations, operated by AngloGold Ashanti (Dwomoh, 2017). In recent years, artisanal and small-scale mining has expanded rapidly and now serves as a primary source of employment for many residents. Miners typically use rudimentary tools and equipment, including excavators, machine pumps, pickaxes, shovels, and panning methods, to extract gold (Kazapoe et al., 2023). The municipality has also attracted a substantial influx of young adult migrants seeking livelihood opportunities, which contributes to the high proportion of migrant miners in the study (see Table 1). This growth has intensified mining-related psychosocial stressors, making the selected communities well suited for examining the links between work-related stressors, food insecurity, and psychological distress among artisanal miners.

This study targeted active artisanal miners, and hence we purposefully selected, seven communities (Binsere, Nhyiaeso, Gausu, Memrewa, Ntonsua, Apatisu, and Sanso), guided by key informants including community leaders, site operators, and experienced miners. These communities are known for their engagement in artisanal gold mining and differing levels of occupational risk exposure. Before data collection, we conducted a reconnaissance survey in these communities to identify households with at least one active miner, mapping 1,970 eligible households and assigning each a unique identification code to form our sampling frame. Within each community, we applied systematic random sampling using varying intervals to account for differences in household density. In each selected household, one eligible miner was randomly chosen via balloting. In cases where more than one miner who met the eligibility criteria resided in a household, a further draw determined the final respondent. Recognizing that many miners spend extended periods at mining sites, we supplemented household recruitment with on-site sampling within the same study communities to minimize selection bias. At each site, miners not captured through household visits were listed, and one eligible participant was randomly selected via balloting.

Table 1
Overall characteristics of the study sample by psychological distress level (N=664).

Variables	Psychological distress			F/ χ^2 p-value
	Overall sample M \pm SD vs. N (%)	Low Distress M \pm SD vs. N (%)	High Distress M \pm SD vs. N (%)	
Age (years)	28.82 \pm 8.17	25.92 \pm 7.70	30.07 \pm 8.06	<.001
Gender				
Male	560 (84.3)	176 (88.0)	384 (82.8)	.088
Female	104 (15.7)	24 (12.0)	80 (17.2)	
Marital status				
Single	432 (65.1)	152 (76.0)	280 (60.3)	<.001
Married	160 (24.1)	24 (12.0)	136 (29.3)	
Cohabiting	48 (7.2)	8 (4.0)	40 (8.6)	
Divorced/Separated	24 (3.6)	16 (8.0)	8 (1.7)	
Educational level				
No formal education	128 (19.3)	0 (0.0)	128 (27.6)	<.001
Basic education	272 (41.0)	112 (56.0)	160 (34.5)	
Secondary education	232 (34.9)	56 (28.0)	176 (37.9)	
Tertiary education	32 (4.8)	32 (16.0)	0 (0.0)	
Resident status				
Native	320 (48.2)	80 (40.0)	240 (51.7)	.006
Migrant	344 (51.8)	120 (60.0)	224 (48.3)	
Living arrangements				
Living alone	336 (50.6)	104 (52.0)	232 (50.0)	.004
Living with family	264 (39.8)	88 (44.0)	176 (37.9)	
Living with friends/colleagues	64 (9.6)	8 (4.0)	56 (12.1)	
Average work duration (years)	5.95 \pm 5.30	5.59 \pm 4.86	6.10 \pm 5.48	.258
Food insecurity (R: 9-45)	17.20 \pm 7.49	11.96 \pm 4.84	19.47 \pm 7.30	<.001
Food insecurity (group)				
Food secured	184 (27.7)	120 (60.0)	64 (13.8)	<.001
Marginally secure	368 (55.4)	24 (12.0)	344 (74.1)	
Food insecure	112 (16.9)	56 (28.0)	56 (12.1)	
Psychoactive substance intake				
Alcohol Use				
No	134 (20.2)	38 (19.0)	96 (20.7)	.619
Yes	530 (79.8)	162 (81.0)	368 (79.3)	
Tobacco Use				
No	616 (92.8)	192 (96.0)	424 (91.4)	.035
Yes	48 (7.2)	8 (4.0)	40 (8.6)	
Tramadol Use				
No	457 (68.8)	112 (56.0)	345 (74.4)	<.001
Yes	207 (31.2)	88 (44.0)	119 (25.6)	
Work stress (R:0-16)	16.84 \pm 5.91	13.26 \pm 4.98	18.39 \pm 5.61	<.001
Personal stress (R:0-16)	5.60 \pm 2.67	5.24 \pm 2.60	5.76 \pm 2.68	.020
Sleep problems (R:2-10)	5.25 \pm 2.32	4.88 \pm 2.38	5.41 \pm 2.28	.006
Physical exhaustion (R: 3-15)	3.01 \pm 2.14	3.64 \pm 2.69	2.74 \pm 1.80	<.001
Comorbidities (0-6)	.73 \pm .91	.56 \pm .75	.81 \pm .96	<.001

Note: N-frequency; M – Mean score; SD – standard deviation. The p-value is based on either the χ^2 test or the independent t-test

Inclusion criteria required participants to be active small-scale miners aged 18 years or older with at least six months of continuous mining experience; individuals not meeting these criteria or declining consent were excluded.

The minimum sample size was calculated using Yamene’s formula (Yamane, 1973) and adjusted for the design effect. Assuming a 50% prevalence in the absence of prior estimates, a 95% confidence level (Z = 1.96), and a 5% margin of error (e = 0.05), with a design effect ($\rho = 1.5$) to account for community-level clustering, the required sample was 499 participants. To compensate for potential non-response and missing data, an oversampling rate of 37% was applied, producing a target

sample of 685. After excluding 10 refusals and 11 incomplete or outlier responses, the final analytic sample comprised 664 participants. This sample size meets both theoretical and empirical benchmarks, providing sufficient statistical power, model stability, and reliable estimates for mediation and multivariate regression analyses (MacKinnon et al., 2007, Columb and Atkinson, 2016).

$$n = \frac{N}{1 + N(e)^2} \times \rho$$

Before data collection started, we sought ethical clearance from the Committee on Human Research, Publications and Ethics (CHRPE) at the School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (Ref: CHRPE/AP/0103/25). Again, permission was sought from the Obuasi Municipal Assembly, and formal engagements were held with local authorities to facilitate community entry and legitimize the study process. Community-level consent was obtained through documented agreements signed by local custodians, including assembly members, site operators, and traditional leaders. Individual participants were provided with detailed information about the study’s purpose, procedures, and voluntary nature. Written informed consent was obtained from all participants. In instances where literacy was a barrier, verbal consent was obtained in the presence of a witness and formally documented. Participants were informed of their right to decline or withdraw from the study at any point without consequence.

Data collection occurred over an eight-week period between 16th February and 14th April 2025. A structured, interviewer-administered questionnaire was used to collect data through face-to-face interviews. The questionnaire was developed using validated instruments previously applied in occupational and public health research in Ghana and across SSA (Dhundayal et al., 2022, Gmayinaam et al., 2024, Omotosho et al., 2025, Quaicoe, 2018). All instruments underwent forward and backward translation between English and Twi by two independent bilingual experts following Beaton et al. (2000) guidelines to ensure semantic and conceptual equivalence. The translated questionnaire was pretested among 25 artisanal miners in a non-study community to assess clarity, cultural relevance, and internal consistency. Minor adjustments were made to enhance content validity and respondent comprehension. Data collection was carried out by seven field teams; each composed of five trained enumerators and one field supervisor. Enumerators were locally recruited and had prior experience in community-based data collection. A two-week training program was held covering the study protocol, informed consent procedures, mental health interviewing, and the use of digital data collection software (Kobo Collect). Field teams were deployed across selected communities using a structured work plan to ensure full coverage of both household- and site-based sampling streams. Interviews were conducted in private settings, either within the respondent’s home or designated safe locations near mining sites, and all interviews were conducted in the local language, Twi, to ensure comprehension and comfort. Each interview lasted approximately 25–35 minutes. Daily quality control checks and random spot audits were performed by field supervisors to ensure accuracy and consistency in data recording. No incentives were provided to participants to prevent participation bias and due to logistical constraints. No participants under 18 years of age were included in the study.

2.1. Variables and measurements

2.1.1. FI (exposure)

FI, the key exposure variable in this study, was assessed using a nine item measure from the Household Food Insecurity Access Scale (HFIAS), which is widely used in LMIC settings to evaluate access-related dimensions of food insecurity (Coates et al., 2007, Deitchler et al., 2010). Some items were linguistically modified to enhance clarity and cultural relevance for the study context, while all original domains and conceptual content were retained. Participants were asked

past 30 days, they experienced various food-related hardships, including: “How often did you worry about not having enough food?” and “How often did you or any household member go to sleep hungry because there was not enough food?” Each item was answered on a 5-point Likert scale: 1 (never), 2 (rarely), 3 (sometimes), 4 (often), and 5 (always). Responses were summed to generate a composite food insecurity score (9–45), with higher scores reflecting more severe experiences of food-related deprivation (Cronbach’s alpha = 0.91). Following established practices and building on categorization frameworks aligned with the USDA Adult Food Security Scale and adaptations used in sub-Saharan Africa (Gebreyesus et al., 2015, Natamba et al., 2015), we categorized households into three food security levels; 1) food secure: scores from 9–18, reflecting no or minimal reported experiences of food insufficiency or concern; 2) marginally food secure: scores from 19–26, indicating moderate anxiety about food supply or occasional compromise in food quality and intake; and 3) food insecure: scores from 27–45, reflecting frequent or severe disruptions in food access, intake, or hunger-related experiences. This approach allows a more nuanced understanding of the spectrum of food insecurity among individuals, going beyond binary classifications to account for varying degrees of vulnerability and exposure.

2.1.2. PD (outcome)

Psychological distress, the main outcome variable, was measured using a ten-item instrument adapted from the Kessler Psychological Distress Scale (K10), a validated tool for detecting non-specific psychological distress in population-based surveys (Kessler et al., 2002). Participants were asked how often they experienced symptoms such as feeling nervous, hopeless, restless, worthless, or depressed over the past 30 days. Sample items included: “During the last 30 days, how often did you feel that everything was an effort?” and “How often did you feel so depressed that nothing could cheer you up?” Each item was rated on a 5-point Likert scale ranging from 1 (none of the time) to 5 (all of the time). A total PD score was computed by summing the responses across the ten items, resulting in a score range of 10 to 50, where higher scores indicate higher levels of PD. The psychological distress scale showed high internal consistency in this study (Cronbach’s alpha = 0.89). We categorized the PD variable using an adapted scoring approach based on prior literature and established K10 scoring thresholds (Kessler et al., 2002, Andrews and Slade, 2001, Smout, 2019). Specifically, participants with total scores ranging from 10 to 29 were classified as having a low psychological distress level. Those with scores ranging from 30 to 50 were categorized as experiencing high psychological distress, suggesting a greater likelihood of clinically significant symptoms such as anxiety or depressive disorders.

2.2. Potential mediators

2.2.1. Work stress

Work stress (WS) was assessed using the 4-item Job Content Questionnaire (JCQ) Work-Related Stress Subscale (Karasek et al., 1998). The JCQ measures work-related stress on a 5-point scale (0 = never to 4 = very often). Questions assess job demands, control, and work pressure (e.g., “In the last month, how often have you felt that your job requires working very fast?”). The scale ranged from 0–16, with higher scores suggesting a higher burden of chronic health conditions. In the current study, the variable showed acceptable internal consistency ($\alpha = 0.75$).

2.2.2. Sleep problems

Sleep problems (SP) were assessed using two self-reported items adapted from the WHO Disability Assessment Schedule 2.0 (WHODAS 2.0) (Konecky et al., 2014). Participants were asked: (1) “Over the past 30 days, how much of a problem did you have with sleeping, e.g., falling asleep, waking up frequently during the night, or waking up too early in the morning?” and (2) “Over the past 30 days, how much of a problem did you have due to not feeling rested and refreshed during the day (for example,

feeling tired, not having energy)?” Responses were recorded on a 5-point Likert scale ranging from 1 (none) to 5 (extreme). A composite sleep problems index was created (range: 2–10), with higher scores indicating greater sleep disturbances. Cronbach’s alpha for the scale in this study was 0.83.

2.2.3. Physical exhaustion

Physical exhaustion (PE) was measured using a 3-item scale assessing levels of fatigue related to daily activities. The items included statements such as “I feel physically worn out at the end of the day,” each rated on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). An overall score was 3–15, with higher scores indicating greater levels of physical exhaustion (Cronbach’s alpha=0.78).

2.2.4. Personal stress

Personal stress (PS) was assessed using items from the 4-item Perceived Stress Scale (Cohen et al., 1983), focusing on stress in relation to personal and interpersonal challenges. Participants rated how often they experienced stress-related feelings such as being overwhelmed or unable to control important things in life, using a 5-point scale from 0 (never) to 4 (very often). An overall score was 0–16, with higher scores indicating greater personal stress (Cronbach’s alpha=0.72).

2.2.5. Comorbidities

Participants self-reported whether they had ever been diagnosed with any of six chronic health conditions: hypertension, diabetes, asthma, arthritis, heart disease, or depression, using a binary response format (1=yes, 0=no). A comorbidity index was generated by summing the number of reported diagnoses. The scale ranged from 0–6, with higher scores suggesting a higher burden of chronic health conditions.

2.2.6. Covariates

In our analysis, regression models were controlled for a wide range of covariates, selected in agreement with prior research. Sociodemographic variables included age (measured in years), sex (male = 1; female = 0), marital status (single = 0; married = 1; cohabiting = 2; divorced/widowed = 3), educational attainment (no formal education=0; primary/basic = 1; secondary = 1; tertiary/higher = 2), residential status (native=1; migrant=0), work duration (continuous in years) and living arrangements (living alone = 0; living with family=1; living with friends/colleagues = 3). Lifestyle-related variables, including alcohol intake, tobacco use, and tramadol consumption, each measured as binary indicators, were included as controlled factors. Participants were asked whether they had engaged in these behaviors in the past 30 days, with responses coded as 1 (yes) and 0 (no) for each variable.

2.3. Data analysis

Statistical analyses were performed using SPSS 25.0 (SPSS, Inc., IBM, Armonk, NY, USA) with $\alpha=0.05$ as the statistically significant level (Preacher and Hayes, 2008). We employed descriptive statistics to describe the attributes of the participants. Categorical variables were presented as counts/proportions, while continuous variables were depicted as means/standard deviations. Group differences between low psychological distress and high psychological distress levels were examined using chi-square tests (categorical variables) and t-tests (continuous variables). Next, Pearson’s zero-order correlations were computed to examine the association between the core study variables, including food insecurity, psychological distress, work stress, personal stress, sleep problems, physical exhaustion, and comorbidities. Following this, multivariate Ordinary Least Squares (OLS) models evaluated the association between FI and PD. We fitted three separate models: Model 1 regressed PD on FI status without adjusting for any covariates. Model 2 added all socio-demographic and lifestyle-related

variables to control their influence on the FI-PD link. This approach allows us to assess whether the FI-PD link weakens after accounting for these crucial variables before adjusting for the mediator factors. Finally, in Model 3, we included all socio-demographic and lifestyle variables from Model 2, in addition to the potential mediating factors. We performed the mediation analysis to understand how the potential mediators explain the association between FI and PD using Model 4 of Hayes' PROCESS macro 4.0 (Hayes, 2017). The bootstrapping procedure (5000 times) provided 95% confidence intervals (CI). It evaded the power challenges by asymmetries and other non-normality forms in the indirect effects' sampling distribution (MacKinnon et al., 2007), each model adjusted for sociodemographic and lifestyle variables. The fully mediated effect was considered statistically significant if the 95% CI of the mean estimates did not contain zero (0).

3. Results

The final analytic sample comprised 664 artisanal miners in Ghana. The sample characteristics are summarized in Table 1. The mean (SD) age was 28.82 (8.17) years, with a majority being male (84.3%) and single (65.1%). Most participants had either basic (41%) or secondary (34.9%) education, and over half (51.8%) were migrants. About 50.6% lived alone, and the average work duration was 5.95 (5.30) years. Food insecurity was prevalent, with a mean score of 17.20 (7.49), with 16.9% and 55.4% of the miners being food insecure and marginally food secure, respectively. Notably, 31.2% reported tramadol use, while 7.2% used tobacco and 79.8% consumed alcohol. Participants with high distress were more likely to be married or cohabiting and had lower educational attainment, with 27.6% having no formal education compared to none in the low-distress group. Food insecurity, work stress, personal stress, sleep problems, and tramadol use were significantly more common among those with high psychological distress. Mean scores for work stress (M = 18.39 vs. 13.26) and food insecurity (M = 19.47 vs. 11.96) were markedly higher among this group. See Table 1 for details.

Table 2 presents Pearson's zero-order bivariate correlation matrix of the key continuous variables. Psychological distress showed strong positive correlations with FI (r = 0.94, p < .001) and WS (r = 0.82, p < .001), and moderate correlations with PS (r = 0.44, p < .001) and SP (r = 0.40, p < .001). Likewise, food insecurity was moderately correlated with WS (r = 0.67, p < .001) and PS (r = 0.45, p < .001), while showing weaker associations with PE (r = 0.28, p < .001) and comorbidities (r = 0.13, p < .001). Although some associations were weak, these correlations met the statistical assumptions necessary for conducting further multivariate and mediation analyses.

Table 3 presents a series of OLS regressions examining the association between FI and PD among artisanal miners in Ghana. Model 1 provides the unadjusted estimates for the association between FI and PD. Model 2 controls for socio-demographic variables. Model 3 further adjusts for the potential mediators of the FI-PD link. In the full model, greater FI was significantly associated with higher levels of PD. Specifically, both food-secure (β = 0.340, S.E. = 0.460, 95% CI = 6.397, 8.203) and marginally food-secure (β = 0.693, S.E. = 0.476, 95% CI =

12.507, 14.377) individuals reported significantly lower psychological distress levels than food-insecure individuals. The R² change between models 1 and 3 was .117, suggesting that the inclusion of control variables provide a better model to explained the variance in PD.

We standardized the data, and the potential parallel mediating effects of psychosomatic factors in the association between FI and PD were analyzed using adjusted Model 4 in the PROCESS macro plug-in. The results in Table 4 showed a significant indirect effect from higher levels of FI to increased levels of PD through WS (indirect effect β = 0.2925, 95% bootstrapping CI = 0.2645 to 0.3217), accounting for approximately 24.46%, PS (indirect effect β = 0.0227, 95% bootstrapping CI = 0.0103 to 0.0367), representing 1.90%, SP (indirect effect β = 0.0153, 95% bootstrapping CI = 0.0081 to 0.0237), accounting for 1.30%, PE (indirect effect β = 0.0080, 95% bootstrapping CI = 0.0009 to 0.0158), accounting for 0.70%, and comorbidities (indirect effect β = 0.0114, 95% bootstrapping CI = 0.0048 to 0.0190), accounting for 0.95% of the total effect. Fig. 2(a-e) presents the unstandardized regression coefficients in each hypothesized pathway.

4. Discussion

This study examined the association between FI and PD among artisanal miners, as well as the potential mediating role of psychosomatic factors in this association. After adjusting for relevant socio-demographic and health-related variables, greater FI was significantly associated with higher levels of PD. Thus, individuals who were fully or marginally food-secure reported notably lower levels of psychological distress compared to their food-insecure counterparts. Further, the parallel mediation analysis revealed that work stress, personal stress, sleep problems, physical exhaustion, and comorbidities are significant mediators in the FI-PD link. These findings provide empirical support for our study hypotheses that FI undermines psychological well-being through elevated psychosomatic strain. The results highlight the critical need for policies and interventions that address FI while also considering the psychosocial stressors faced by vulnerable mining populations.

4.1. Interpretations and mechanisms

Several previous studies from LMICs have examined the relationship between FI and PD, consistently demonstrating a positive association across diverse populations and contexts (Jandaghian-Bidgoli et al., 2024, Owusu-Sarpong et al., 2024, Hasan et al., 2021). For instance, in a cross-sectional study involving 34,129 individuals aged ≥50 years from six LMICs (China, Ghana, India, Mexico, Russia, and South Africa), Smith et al. (2021) found that severe FI was significantly associated with higher odds of depression (OR = 2.43; 95% CI: 1.65–3.57) compared to food-secure individuals. Similarly, an analysis of data from 149 countries reported that FI was associated with poorer mental health outcomes, including increased negative experiences and decreased positive experiences, independent of socioeconomic status (Jones, 2017). In advanced countries, the relationship between FI and PD has also been well-documented. A study conducted in the United States during the

Table 2
Zero-order Pearson's correlations between the principal study continuous variables.

SN	Variables	1	2	3	4	5	6	7
1	Food insecurity	1						
2	Psychological distress	.944**	1					
3	Work stress	.665**	.820**	1				
4	Personal stress	.453**	.444**	.241**	1			
5	Physical exhaustion	.279**	.264**	.132**	.197**	1		
6	Sleep problems	.390**	.397**	.251**	.260**	.276**	1	
7	Comorbidities	.134**	.159**	.003	.162**	.009	.001	1

***p < .001

**p < 0.05

Table 3
Multivariable analyses of the association between food insecurity and psychological distress among ASMs: Linear Regressions.

Variables	Model 1			Model 2			Model 3		
	β (S.E)	t	95 CI	β (S.E)	t	95CI	β (S.E)	t	95 CI
Food secured VS food insecure	.707 (.493) ^{***}	30.751	14.196, 16.133	.700 (.530) ^{***}	28.329	13.966, 16.046	.340 (.460) ^{***}	15.873	6.397, 8.203
Marginally food secured VS food insecure	1.233 (.444) ^{***}	53.647	22.950, 24.694	1.204 (.467) ^{***}	49.745	22.332, 24.167	.693 (.476) ^{***}	28.229	12.507, 14.377
Age (years)				.137 (.027) ^{***}	5.882	.107, .215	.090 (.018) ^{***}	5.786	.070, .143
Gender (Male Vs female)				.042 (.468) [*]	2.392	.200, 2.040	.032 (.330) [*]	2.589	.206, 1.504
Residence status (Native VS migrant)				.020 (.340)	1.144	-.279, 1.057	.024 (.229) [*]	2.011	.011, .911
Work duration (years)				-.006 (.039)	-.282	-.088, .066	-.073 (.027) ^{***}	-4.951	-.184, -.080
Marital status (Ref: Single)									
Married				-.084 (.521) ^{***}	-3.605	-2.904, -.856	-.023 (.359)	-1.458	-1.228, .181
Cohabiting				.030 (.647)	1.731	-.150, 2.391	.004 (.451)	.353	-.727, 1.045
Divorced/Separated				-.096 (.874)	-5.677	-6.680, -3.247	-.048 (.605) ^{***}	-4.092	-3.666, -1.288
Educational attainment (Ref: No formal education)									
Primary/Basic education				-.030 (.482)	-1.216	-1.534, .360	.021 (.361)	1.137	-.298, 1.120
Secondary education				.004 (.529)	.141	-.963, 1.112	.060 (.377) ^{**}	3.213	.471, 1.953
Tertiary education				-.019 (.827)	-1.051	-2.494, .755	-.025 (.597)	-1.889	-2.301, .044
Living arrangement (Ref: living alone)									
Living with family				-.057 (.416) ^{**}	-2.692	-1.938, -.303	-.015 (.297)	-.986	-.875, .290
Living with friends/colleagues				.017 (.590)	.965	-.590, 1.728	.022 (.420)	1.787	-.074, 1.577
Psychoactive substance intake									
Alcohol				-.054 (.387) ^{**}	-3.345	-2.057, -.535	-.014 (.265)	-1.289	-.863, .179
Tobacco				.039 (.651) [*]	2.223	.169, 2.725	.023 (.471)	1.829	-.064, 1.787
Tramadol				.000 (.347)	.002	-.682, .683	-.021 (.232)	-1.837	-.882, .029
Work stress							.427 (.026) ^{***}	26.891	.646, .748
Personal stress							.086 (.047) ^{***}	6.647	.218, .401
Physical exhaustion/fatigue							.076 (.061) ^{***}	5.640	.224, .463
Sleep problems							.059 (.055) ^{***}	4.462	.137, .353
Comorbidities							.081 (.118) ^{***}	7.258	.623, 1.085
Model fitting information									
Constant	8.357 (.389) ^{***}	21.494	7.594, 9.121	1.296 (4.390) ^{**}	3.386	1.844, 6.935	-3.956 (.955)	-4.144	-5.830, -2.081
R Square	.817			.845			.934		
F-statistic	1476.724			206.632			406.433		

Note: β = standardized regression coefficient; S.E= robust standard errors in parenthesis; CI= confidence interval; ASMs= artisanal and small-scale miners

* p<.05
** p<.005
*** p<.001.

COVID-19 pandemic revealed a strong dose-response relationship between FI and psychological distress, anxiety, and depression. Specifically, individuals with very low food security had significantly higher prevalence rates of psychological distress (47.7%), depression (48.1%), and anxiety (49.4%) compared to those with high or marginal food security (Sundermeir et al., 2021). Additionally, in a systematic review and meta-analysis encompassing 19 studies with over 372,000 participants, Pourmotabbed et al. (2020) found that FI was associated with increased odds of depression and stress. Interestingly, the present findings not only corroborate these findings obtained in both Global North and South but also show that the significant association between food insecurity and psychological distress exists among artisanal miners in SSA.

Several hypotheses may be proposed as to the underlying mechanism linking FI and PD. In this study, personal stress, work-related stress, sleep problems, physical exhaustion, and comorbidities significantly mediated the relationship between FI and PD among artisanal miners. Thus, food insecurity, characterized by limited access to adequate and nutritious food, can heighten personal stress due to persistent anxiety over the availability and adequacy of food, financial hardship, and the

pressure to support family members (Myers, 2020, Hasan et al., 2021). This persistent stress response activates the body’s physiological stress systems, particularly the hypothalamic–pituitary–adrenal (HPA) axis, leading to elevated cortisol levels that impair emotional regulation and increase vulnerability to psychological dysfunction (Herman et al., 2016, Mbiydzenyuy and Qulu, 2024). Notably, artisanal miners in Ghana often operate in informal, unregulated environments where income volatility, hazardous conditions, and the lack of social protection converge. As such, food insecurity may act as a chronic stressor that interacts with an already strained ecosystem—exacerbating stress via occupational burnout, physical depletion, and low dietary resilience.

Similarly, work stress mediated the FI-PD link among miners. Thus, previous research suggests that FI, marked by limited access to adequate and nutritious food, can lead to physical exhaustion, low energy levels, and fatigue, impairing concentration at work and performance (Babashahi et al., 2021). In turn, work stress is known to predict psychological distress through burnout, emotional fatigue, and disrupted work-life balance (Adanaqué-Bravo et al., 2023). Moreover, poor dietary habits, including irregular eating patterns or a lack of balanced meals, can lead to fluctuations in blood sugar levels, contributing to nighttime

Table 4
Mediating variables in the association between FI and PD in ASMs based on bootstrapping estimates.

Path model	Effect	B	BootsSE	Boots 95%CI	% mediated
FI→work-stress→PD	Total effect	1.1957	.0168	1.1627, 1.2288	24.46%
	Direct effect	.8458	.0151	.8161, .8754	
	Indirect effect	.2925	.0146	.2645, .3217	
FI→personal stress→PD	Total effect	1.1957	.0168	1.1627, 1.2288	1.90%
	Direct effect	.8458	.0151	.8161, .8754	
	Indirect effect	.0227	.0067	.0103, .0367	
FI→sleep problems→PD	Total effect	1.1957	.0168	1.1627, 1.2288	1.30%
	Direct effect	.8458	.0151	.8161, .8754	
	Indirect effect	.0153	.0040	.0081, .0237	
FI→physical exhaustion→PD	Total effect	1.1957	.0168	1.1627, 1.2288	0.70%
	Direct effect	.8458	.0151	.8161, .8754	
	Indirect effect	.0080	.0038	.0009, .0158	
FI→comorbidities→PD	Total effect	1.1957	.0168	1.1627, 1.2288	0.95%
	Direct effect	.8458	.0151	.8161, .8754	
	Indirect effect	.0114	.0036	.0048, .0190	

Note: B=Unstandardized regression coefficients are reported; FI= food insecurity; PD= psychological distress; ASMs= artisanal and small-scale miners; BootSE=Bootstrapping standard error; CI= confidence intervals. Each model was adjusted for age, sex, marital status, educational attainment, living arrangements, work duration, and psychoactive substance intake. Confidence intervals and standard errors are based on 5000 bootstrap samples and a bias correction of 95%. The empirical 95% confidence interval does not overlap with zero.

wakefulness or difficulty sleeping (Theorell-Haglöw et al., 2020). Poor sleep quality, in turn, is associated with irritability, depressive symptoms, and heightened emotional reactivity, all of which contribute to psychological distress (Okun et al., 2018, Whiting et al., 2023).

Further, food insecurity, involving lack of sufficient calories, proteins, and essential vitamins may cause miners to feel fatigued more quickly, making it difficult for them to perform physically demanding tasks like digging, lifting, or transporting materials (Tardy et al., 2020). Physical exhaustion may, in turn, contribute to the onset of psychological distress via disruption of neurobiological functioning and heightened emotional strain (Viertö et al., 2021). Finally, individuals facing FI often rely on low-cost, calorie-dense but nutrient-poor foods that are high in sugars, fats, and sodium, thereby contributing to the development of conditions such as obesity, hypertension, type 2 diabetes, and cardiovascular disease (Chang et al., 2021, Carvajal-Aldaz et al., 2022). These chronic comorbidities can, in turn, lead to PD through persistent physical discomfort, functional limitations, loss of independence, and the emotional burden of long-term illness management (Leung et al., 2020, S et al., 2023).

It is also important to note that since the mediators tested in this study explained a substantial portion (28.36%) of the relationship between FI and PD, other mechanisms are also likely to contribute. For instance, food insecurity is associated with poor dietary quality, often leading to deficiencies in essential nutrients such as iron, magnesium, and B vitamins (Basiry et al., 2024), which are critical for brain function and emotional regulation (Lopes et al., 2023). Among artisanal miners, long hours of physically demanding labor with minimal access to

nutritious meals may heighten the risk of such deficiencies (Matamala and Aguayo, 2021). Nutrient shortfalls (malnutrition), particularly of vitamin B12 and omega-3 fatty acids, have been linked to mood disturbances and depressive symptoms through their role in neurotransmitter synthesis and inflammatory processes (Zielińska et al., 2023). In addition, FI has been associated with elevated systemic inflammation (Leddy et al., 2019), which is known to affect mental health adversely.

While the biological underpinnings of these associations remain incompletely understood, inflammatory responses may exacerbate stress sensitivity and mood disorders (Slavich and Irwin, 2014). Environmental and behavioral factors such as the poor living, psychoactive substance use and working conditions often encountered in artisanal mining communities, marked by overcrowded shelters, exposure to noise, and lack of safety should also be considered when examining the broader impacts of FI, as they are associated with both reduced dietary quality and adverse mental health outcomes (Armah et al., 2016, Landrigan et al., 2022). Critically, these biological explanations may be especially relevant in artisanal mining contexts where exposure to environmental toxins (e.g., mercury) may compound nutrient deficiencies and immune dysregulation. In this light, psychosomatic pathways linking FI to PD are not only multifactorial but environmentally contingent—requiring interventions that integrate nutritional, occupational, and environmental health perspectives.

The strengths of the current study include its focus on artisanal miners, a vulnerable and often overlooked group, providing valuable insights into how food insecurity interacts with psychological factors to exacerbate mental health distress in this unique occupational setting. The study also contributes to a better understanding of the complex pathways linking food insecurity to psychological distress through mediators like work-related stress, anxiety, and social isolation. By utilizing validated scales to measure key variables, the study ensures the reliability and validity of its findings. Additionally, the study's mediation analysis offers an innovative methodological approach to understanding the impact of food insecurity on mental health, particularly within sub-Saharan Africa's informal labor sector. However, there are some limitations to consider. First, the use of self-reported data for food insecurity and psychological distress could introduce potential biases, such as recall bias or social desirability bias. While self-reports are commonly used in such studies, future research might benefit from integrating objective measures or longitudinal tracking to strengthen the findings further. Second, the cross-sectional design means that causal relationships cannot be definitively established, and the study primarily identifies associations between food insecurity and psychological distress. A longitudinal design would help clarify the directionality of these relationships over time. Despite these limitations, the study provides significant and valuable contributions to the understanding of food insecurity and mental health among artisanal miners.

5. Conclusions and implications

This study among artisanal miners in Ghana revealed that FI was significantly associated with higher levels of PD, with work stress, sleep problems, physical exhaustion, and comorbidities partially mediating this relationship. Our findings have both policy and health implications. From a policy perspective, addressing food insecurity should be prioritized. The provision of consistent and reliable access to nutritious food in artisanal mining communities is essential. This could involve community-based food security initiatives, such as food distribution programs or local agriculture projects that empower miners to grow their food. Additionally, creating support systems for miners that provide food assistance during periods of financial strain can significantly alleviate the immediate effects of food insecurity. Furthermore, mental health screenings and psychosocial support programs should be integrated into occupational health policies for artisanal miners. These programs should focus on reducing work stress and managing psychosomatic factors such as sleep problems and physical exhaustion. Policy

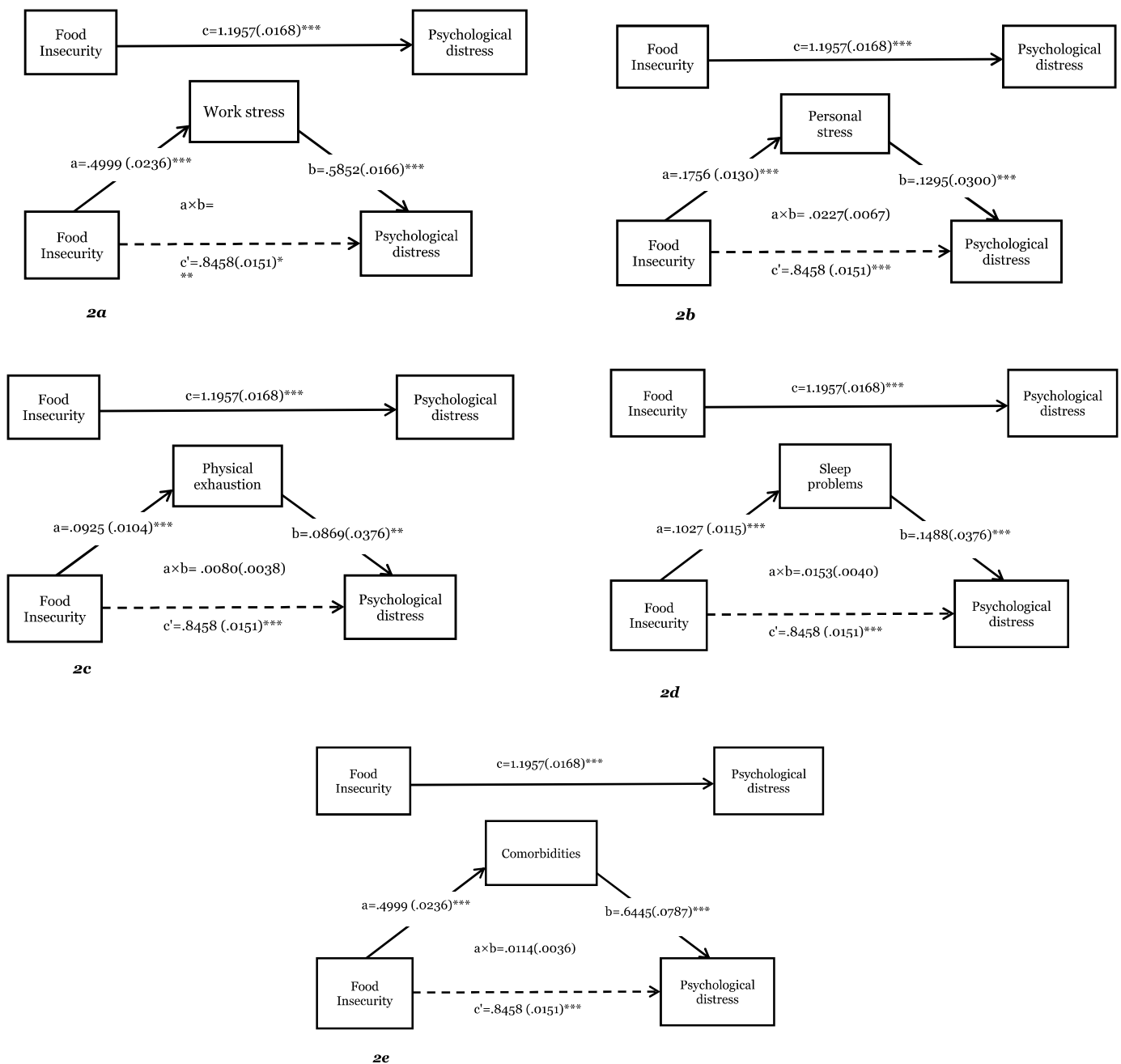


Fig. 2. Mediating framework for the association between food insecurity and psychological distress among ASMs.

measures that strengthen social safety nets, improve labor rights protections, and provide financial support for food access would significantly reduce the mental health burden caused by food insecurity. Future research should explore the effectiveness of these interventions in addressing both food insecurity and mental health among artisanal miners, with a focus on longitudinal data to validate the long-term impact of such initiatives.

Ethics approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Committee on Human Research, Publications and Ethics (CHRPE) at the School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (Ref: CHRPE/AP/0103/25). Informed consent was obtained from all individual participants included in the study.

Consent for publication

All participants provided informed consent for their data to be used for research and publication purposes. No identifiable personal data or images are included in this publication.

Availability of data and materials

All data used in this study are available from the corresponding author upon reasonable request.

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CRedit authorship contribution statement

Emmanuel Nyaaba: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Kabila Abass:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Vanessa F. Epis:** Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing. **Evans Adu-Siaw Annor:** Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing. **Lawrence Guodaar:** Supervision, Methodology, Validation, Writing – review & editing. **Razak M. Gyasi:** Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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