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Joint Food and Water Insecurity Had a Multiplicative Effect on Women's Depression in Urban Informal Settlements in Makassar, Indonesia during the COVID-19 Pandemic

Isabel Charles^{1,*}, Allison Salinger¹, Rohan Sweeney², Becky Batagol³, S. Fiona Barker⁴, Sudirman Nasir^{5,6}, Ruzka R. Taruc⁵, Naomi Francis³, Thomas Clasen⁷, Sheela S. Sinharoy¹, for the RISE consortium⁸

¹ Hubert Department of Global Health, Rollins School of Public Health, 1518 Clifton Rd NE, Emory University, Atlanta, GA, USA; ² Center for Health Economics, Monash Business School, Monash University, Melbourne, Australia; ³ Monash Sustainable Development Institute and Faculty of Law, Monash University, Melbourne, Australia; ⁴ School of Public Health and Preventative Medicine, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, Australia; ⁵ Faculty of Public Health, Hasanuddin University, Makassar, Indonesia; ⁶ Universitas Hasanuddin, Centre of Excellence for Interdisciplinary and Sustainability Sciences, Makassar, Indonesia; ⁷ Gangarosa Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA

ABSTRACT

Background: Women living in urban informal settlements may be particularly vulnerable to the detrimental effects of the COVID-19 pandemic because of increased economic and psychosocial stressors in resource-limited environments.

Objectives: The objective of this study was to assess the associations between food and water insecurity during the pandemic and depression among women living in the urban informal settlements in Makassar, Indonesia.

Methods: We implemented surveys at 3 time points among women enrolled in the Revitalizing Informal Settlements and their Environments trial. Depression was measured using the Center for Epidemiologic Studies Depression Scale—10 (CESD-10) between November and December 2019 and again between February and March 2021. Food insecurity was measured using questions from the Innovation for Poverty Action's Research for Effective COVID-19 Responses survey and water insecurity was measured using the Household Water Insecurity Experiences Short Form. Both were measured between August and September 2020. We built 3 multivariate quantile linear regression models to assess the effects of water insecurity, food insecurity, and joint food and water insecurity during the COVID-19 pandemic on CESD-10 score.

Results: In models with the full sample ($n = 323$), food insecurity (β : 1.48; 95% CI: 0.79, 2.17), water insecurity (β : 0.13; 95% CI: -0.01, 0.26), and joint food and water insecurity (β : 2.40; 95% CI: 1.43, 3.38) were positively associated with CESD-10 score. In subgroup analyses of respondents for whom we had prepandemic CESD-10 scores ($n = 221$), joint food and water insecurity (β : 1.96; 95% CI: 0.78, 3.15) maintained the strongest relationship with CESD-10 score. A limitation of this study is that inconsistency in respondents from households across the survey waves reduced the sample size used for this study.

Conclusions: Our results find a larger association between depression and joint resource insecurity than with water or food insecurity alone, underlining the importance of addressing food and water insecurity together, particularly as they relate to women's mental health and well-being.

Keywords: COVID-19, depression, food insecurity, urban informal settlements, water insecurity

Abbreviations: CESD-10, Center for Epidemiological Studies Depression Scale-10; HWISE, Household Water Insecurity Experiences scale; IPA RECOVER, Innovation for Poverty Action's Research for Effective COVID-19 Responses survey; LMICs, low- and middle-income countries; RISE, Revitalizing Informal Settlements and their Environments; SDGs, Sustainable Development Goals; WASH, water, sanitation and hygiene.

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* Corresponding author: E-mail address: icharle@emory.edu (I. Charles).

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Introduction

The COVID-19 pandemic had detrimental effects on the well-being of people globally, as the world faced economic, political, and social shocks that disrupted daily life [1–3]. COVID-19 impacted psychological well-being in high-, middle-, and low-income countries through increased rates of anxiety, depression, posttraumatic stress disorder, and other forms of psychological distress, not only among those who contracted the virus [3–6]. Several studies have found that women in low- and middle-income countries (LMICs) may be particularly vulnerable to increased depression during the COVID-19 pandemic [4, 6, 7].

Women in LMICs often face profound consequences from economic hardships, such as those resulting from the COVID-19 pandemic: as primary caregivers, women may be most affected when household resources are limited, and are more likely to make sacrifices (e.g., skipping meals) as a way to alleviate financial stress for their households [8, 9]. Early on in the pandemic, women living in urban informal settlements were identified as a particularly vulnerable population, as crowded living spaces, inadequate housing, dependence on an informal economy, and poor access to water as well as sanitation services may have compounded the social, health, and economic impacts of COVID-19 [10]. Furthermore, women in urban informal settlements are less likely to be employed than men, increasing their economic vulnerability [11]. As a part of the economic and social consequences of the COVID-19 pandemic, research has found high reports of water and food insecurity in low-income settings, particularly among women [6, 12].

Previous literature has identified positive associations between food and water insecurity and depression in LMICs [13, 14], and a small handful of studies have found these associations in the context of urban informal settlements [15–18]. Because women tend to bear the burden of household food and water collection as well as serve as caregivers, they also bear an increased burden of poor mental health related to resource insecurity [17, 19, 20]. Therefore, it is possible that food and water insecurity, including due to market closures, mobility restrictions, and economic hardship, may have led to increased depression among women living in urban informal settlements during the COVID-19 pandemic.

Although some studies have assessed food insecurity related to mental health *during* the COVID-19 pandemic [9, 21–23], there is a lack of studies that explore the complex associations between the COVID-19 pandemic, food and water insecurity, and mental health in informal settlements or that attempt to answer questions about causality by adjusting for prepandemic mental health. With the exception of the study by Logie et al. [22] on refugee youth in Kampala, studies assessing the relationships between depression and resource insecurity during the COVID-19 pandemic have not had both prepandemic and during-pandemic data on depression, which is necessary for understanding baseline levels of mental health. This gap in the literature is likely because of the fact that there is little ongoing research in urban informal settlements in general [24]. As also noted by Logie et al. [22], living in urban informal settlements comes with everyday stressors that contribute to poor mental and physical health [24, 25]. Depression, water insecurity, and food insecurity in urban informal settlements are not constrained to the COVID-19 pandemic [15, 16, 26, 27]. Controlling for

prepandemic depression levels helps to disentangle the role that food and water insecurity play on levels of depression measured during the COVID-19 pandemic from other factors affecting mental health.

As urban informal settlements continue to grow and play an increasingly important role in urbanization in the Global South, a better understanding of these settings is critical, including for the achievement of Sustainable Development Goal (SDG) 11, which calls for the transformation of urban settlements to be safe and livable settings for all [28]. The United Nations recently called upon practitioners to use recovery from the COVID-19 pandemic to reimagine human settlements as urban centers of resilience and sustainable growth [29]. Understanding how food and water insecurity can impact well-being during shocks and stressors, such as COVID-19 can help inform urban policy and settlement upgrading initiatives, and more generally can provide insight into what factors strengthen resilience among residents of urban informal settlements in the face of adversity.

The objective of this study was to investigate the association between household water and food insecurity and self-reported depression score among women living in urban informal settlements during the COVID-19 pandemic in Makassar, Indonesia. We hypothesized that both food and water insecurity would be associated with heightened depressive symptoms, and that joint food and water insecurity in particular would have the strongest association with depressive symptoms.

Methods

Overview

This study uses survey data collected from the households in urban informal settlements in Makassar, Indonesia through the Revitalizing Informal Settlements and their Environments (RISE) trial. RISE is a randomized control trial in which 24 urban informal settlements in Suva, (Fiji) and Makassar (Indonesia) were assigned to the intervention arm (6 in each city) or to the control arm (6 in each city). In intervention settlements, RISE is collaborating with residents to design and build decentralized water and sanitation infrastructure at the household, neighborhood, and precinct level [30]. Longitudinal assessments of health and well-being as well as human and environmental sampling will be used to assess the impact of infrastructure on the trial's primary (reduced exposure to fecal contamination) and secondary outcomes (including microbial contamination, ecological biodiversity, and well-being) [30]. Additional details on the RISE trial protocol and data already collected can be found in the studies reported by Leder et al. [30] and French et al. [31].

Study setting

Indonesia has experienced rapid population growth in recent decades and an accompanying increase in the development of urban slums [32, 33]. Makassar is the 6th largest city of Indonesia, capital of the province of South Sulawesi, and home to approximately 1.5 million people, with a third of that population living in poverty [34]. The settlements in Makassar involved in the RISE trial vary in size from 2846 to 27,635 m² per settlement, with a population density of approximately 0.02 persons per m² with an average of 4 individuals per household. Makassar has a tropical monsoon climate, prone to climate hazards, such as earthquakes, landslides, and El Niño [35]. Most settlements have

high flood risk being located on flat, low-lying land with limited or no drainage systems [31]. Although municipal piped water is available to at least some of the households in the settlements, the RISE baseline surveys found that approximately 70% of households reported using bottled water as a primary drinking water source [31]. Within the settlements, there are a diversity of ethnic identities, with Makassarese being the majority ethnicity, as well as minority ethnicities, including Bugis, Luwu, Toraja, and Mandar.

Study population and data collection

This study uses 4 waves of a household survey (referred to in this paper as T0, T1, T2, and T3) collected from the intervention and control settlements in Makassar, Indonesia. The household surveys used in this study occurred before the RISE intervention initiation. Data from Suva, Fiji were not included because it did not align temporally with our research question (i.e., data on depression had not been collected after the data on food and water insecurity). Demographic data were pulled from the baseline survey between November and December 2018 (T0). Data on depression in Makassar were collected through in-person household surveys i.e., conducted between November and December 2019 (T1) and telephone surveys between February and March 2021 (T3). Data on food and water insecurity were collected through telephone surveys between September and November 2020 (T2). [Supplementary Table 1](#) shows the timeline of survey collection waves and data collected.

The baseline survey used to collect demographic data is described in detail by French et al. [31]. In the instances when baseline data were not available for a participant (e.g., the woman moved into the settlement after baseline data collection), demographic data were pulled from a subsequent survey wave. The final sample of women included in the study were women for whom we had data from both the T2 and T3 household survey waves.

T1 and T3 targeted adult females (defined as someone aged ≥ 18 y, or someone who was married or had children). Specifically, female primary caregivers in households with children aged < 15 y, and female household heads or other adult females in households with no children aged < 15 y were targeted. Other adult respondents were surveyed if no target respondent was available (see Leder et al. [30] for more details of the survey sampling frame). If no appropriate adult respondent was available, surveyors arranged to return when one of the requested individuals was available. For each wave, ≥ 3 attempts were made across 3 separate days, before the household was classified as missed for that wave. The same respondent was not required across survey waves. T1 data collection occurred via household visits and T3 occurred via phone surveys. During the T3 data collection, the city of Makassar was in the “orange zone” regarding COVID-19 restrictions [36] and was one of the biggest contributors to the COVID-19 case and death counts in Indonesia [37].

T2 survey data were collected by telephone between September and November 2020 (T2). For this wave, enumerators targeted the respondent from the most recent previous survey to enable comparisons across time points. If the previous respondent was not available after 3 call attempts, the enumerator requested to speak with “an adult who is able to answer questions about the health and activities of the whole household.” Data collection occurred during the dry season in Makassar [38]. During T2 data

collection, Indonesia was the second largest contributor to COVID-19 cases in Southeast Asia, and South Sulawesi (the province where Makassar is located) was the fourth largest contributor to cases in Indonesia, following Jakarta and Java [39]. The city was still operating in the “red zone” of COVID-19 restrictions; however, physical distancing was no longer being practiced as distinctly as it was 2 mo earlier [40, 41].

Key variables

The T1 and T3 waves included questions on self-reported depression, financial well-being, and health symptoms. Depression was measured using questions from the Center for Epidemiological Studies Short Depression scale (CESD-10) [42]. The CESD-10 is a 10 question, shortened version of the twenty question Center for Epidemiological Studies Depression scale [43]. The questions ask the respondent to rate how often in the last week they have experienced certain depressive symptoms, scored between 0 (rarely or none of the time) and 3 (almost all of the time). Depressive symptoms included: trouble keeping your mind on what you are doing, feeling like everything you do is an effort, feeling fearful, and trouble sleeping. The CESD-10 score is a sum of the 10 responses, with a possible range of 0–30 [42]. The higher the CESD-10 score, the more frequently the individual had experienced depressive symptoms [42].

T2 did not include depression but included questions on food and water insecurity. Water insecurity was measured using the short form of the Household Water Insecurity Experiences (HWISE) scale, known as the HWISE-4 [44], which has been evaluated for validity using data from > 9000 households in 25 LMICs [44]. The HWISE-4 includes 4 questions on problems with water related to worry about having enough water to meet household needs, changing plans or schedule because of problems with water, access to drinking water, and access to water for handwashing. Respondents scored on a scale of 0–3 how frequently they had experienced the listed water problems in the past 4 wk from the following options: never (0), rarely [1], sometimes [2], and often or always [3]. The water insecurity score was a sum of the responses, with a possible range of 0–12 [44]. A household with a score ≥ 4 was considered water insecure [44].

Food insecurity was measured using 2 questions drawn from Innovation for Poverty Action’s Research for Effective COVID-19 Responses (IPA RECOVER) survey [1]. The original IPA RECOVER survey was deployed in 9 countries to $> 30,000$ respondents [1]. In the original IPA RECOVER survey, the questions asked about how many days an individual experienced various food insecurity events within the past week, on a scale of 0–7 d. For the purpose of this survey, the response options were modified to match the scale (never, rarely, sometimes, often, or always) and time frame (in the past 4 wk) of the HWISE items. The modified food insecurity items asked respondents to report how frequently in the past 4 wk the respondent or someone in the respondent’s household had to limit portion size at meals and how many times the respondent or someone in the respondent’s household had to limit the number of meals eaten in a day. Food insecurity was a binary outcome by which participants were considered food insecure if they ever reported having reduced portion sizes or skipped meals in the past 4 wk [1].

We also created an ordinal variable for joint water and food insecurity, with 3 categories for resource insecurity: “joint” (if a

household had an HWISE score >4 AND reported having ever reduced portion sizes or skipped meals in the past 4 wk), “one” (if a household had an HWISE score >4 OR reported having ever reduced portion sizes or skipped meals in the past 4 wk), and “none” (if a household had an HWISE score <4 AND did not report ever having reduced portion sizes or skipped meals in the past 4 wk).

Statistical analysis

Three multivariate quantile regression models were developed for analysis: one using self-reported household food insecurity as the primary predictor, one using self-reported household water insecurity as the primary predictor, and one that used joint food and water insecurity as the primary predictor. The models were adjusted to account for several covariates, as described below, with clustered SEs at the settlement level. The models examining food insecurity and joint insecurity also included fixed effects at the settlement level to account for factors, such as distance to markets [45]. A subanalysis of women who responded to both T1 and T3 was conducted, controlling for CESD-10 score at T1.

In addition, 2 separate sensitivity analyses were conducted. In order to check for consistency in associations between water insecurity and depression scores across rainy and dry seasons, we ran a model in which we replaced T2 HWISE scores with T3 HWISE scores. This sensitivity analysis included all covariates as described below and the CESD-10 score at T1, with clustered SEs at the settlement level. Food insecurity data were not available from other time points so a sensitivity analysis for food insecurity and depression was not possible. A separate sensitivity analysis was conducted removing the wealth index score from all 3 models (water insecurity, food insecurity, and joint insecurity), because findings from the literature on the relationship between wealth and mental health in LMICs have been mixed [46]. Data analysis was conducted using STATA 17.0.

Covariate selection

The following variables were considered a priori as potential covariates because of their relationship with both the exposures (food and water insecurity) and the outcome (depression) based on previous literature [47]: intervention status, wealth index score (calculated through principal components analysis of household asset ownership variables from baseline, constructed for Escobar Carias et al. [48]), disability as defined by the WHO's International Classification of Functioning, Disability, and Health [49] (assessed using the Washington Group Short Set on Functionality [50]), and self-reported financial satisfaction at T3 (measured on an ordinal scale from 1–10, with a high score indicating increased levels of satisfaction). Potential relationships between these variables are shown in [Supplementary Figure 1](#). Owing to the strong theoretical foundations and empirical evidence from other studies in favor of the importance of our selected covariates for depression, all covariates identified a priori were retained in the models except for intervention status. Because the data come from a randomized controlled trial, we checked whether intervention status had any observable relationship with the key outcome of interest, but analysis found no effect; therefore, the intervention status was dropped from the models.

Ethics

Approval for the RISE trial and this substudy was obtained from the participating universities and local institutional review boards, including from Monash University Human Research Ethics Committee (Melbourne, Australia; project ID 9396), the Ministry of Research, Technology and Higher Education Ethics Committee of Medical Research at the Faculty of Medicine, Universitas Hasanuddin (Makassar, Indonesia; protocol UH18020110), Department of Health Promotion and Behavioural Sciences Faculty of Public Health, and Universitas Hasanuddin (Makassar, Indonesia; protocol UH20050235). The RISE program is a randomized control trial registered on the Australian New Zealand Clinical Trials Registry (trial ID: ACTRN12618000633280).

Results

Descriptive analysis

Of the 323 women, $>85\%$ were married and most women had completed primary school as their highest level of education ([Table 1](#)). The average age of women in the study was approximately 40 y at baseline ([Table 2](#)). The majority ethnicity was Makassarese and majority religion was Muslim ([Table 1](#)). Four percent of the study participants reported living with a disability ([Table 1](#)). When asked at T3 about their satisfaction with their current financial situation, the mean response was 5.8 on a scale of 1–10, with a high score indicating increased levels of satisfaction ([Table 1](#)).

The mean CESD-10 score during the pandemic (T3) was 4.33, and the highest score reported was 23 (out of a total possible

TABLE 1

Sociodemographic characteristics of women living in urban informal settlements in Makassar, Indonesia ($N = 323$)

Sociodemographic characteristics	Value
Age, (y) (T0)	40.62 (11.39)
Marital status (T0)	
Single/never married, n/N (%)	17/323 (5.3)
Married, n/N (%)	280/323 (86.7)
Divorced/separated, n/N (%)	12 (3.7)
Widowed, n/N (%)	14 (4.3)
Highest level of schooling completed ¹ (T0)	
Never attended, n/N (%)	13/321 [4]
Primary school, n/N (%)	129/321 [40]
Junior high school, n/N (%)	73/321 (22.7)
Senior high school, n/N (%)	94/321 (29.3)
Academy/trade school/university, n/N (%)	12/321 [4]
Ethnicity ² (T0)	
Makassarese	216/311 (69.5)
Other ³	95/311 (30.5)
Religion ⁴ (T0)	
Muslim	292/309 (96.4)
Other	11/309 (3.6)
Living with disability (T2)	13/323 [4]
Self-reported financial satisfaction, (y), (T3)	5.8 (1.9)

Values are mean (SD) or frequency (percentage) unless otherwise indicated.

¹ 2 observations (0.62%) missing from highest level of schooling completed.

² 12 observations (3.72%) missing from ethnicity.

³ Other ethnicities reported include Bugis, Luwu, Toraja, and Mandar.

⁴ 14 observations (4.33%) missing from religion.

TABLE 2

Descriptive statistics of depression score before and during the COVID-19 pandemic and food and water insecurity during the COVID-19 pandemic of women living in urban informal settlements in Makassar, Indonesia ($N = 323$)

Variable	Value
Depression (T1/T3)	
T1 (Prepandemic) CESD-10 score ¹	4 [3]
T3 (During Pandemic) CESD-10 score	4 [4]
Resource insecurity (T2)	
Water insecurity	
Water secure, n/N (%)	265/323 (82)
Water insecure, n/N (%)	58/323 [18]
HWISE score	0 [2]
Food insecurity ²	
Food secure	255/320 (78.9)
Food insecure	65/320 (20.1)
Joint insecurity ³	
Both	21/320 (6.5)
Either food or water	81/320 [25]
Neither	218/320 (67.5)
At least one	102/320 (31.4)

Values are median (IQR) or frequency (percent) unless otherwise indicated.

CESD-10, Center for Epidemiological Studies on Depression Scale, 10 item version; HWISE, Household Water Insecurity Experiences

¹ 102 (31.58%) missing from CESD-10 score prepandemic. Variable used as control in subanalysis of only women for whom CESD-10 score prepandemic was available.

² 3 (0.93%) missing from food insecurity

³ 3 (0.93%) missing from joint insecurity

score of 30) (Table 3). In a t test examining the differences between CESD-10 score before (T1) and during the COVID-19 pandemic (T3), there was no statistically significant difference (μ [diff] = 0.25; t : 1.07; 95% CI: -0.21, 0.71) (Table 2). The mean HWISE-4 score among households was 1.34, with the highest reported score being 12 (of a total possible score of 12) (Table 2). Supplementary Figure 2 shows the distribution of responses to the HWISE-4 questions. Approximately 18% of households were classified as water insecure based on HWISE-4 guidelines (Table 2). Supplementary Figure 3 shows the distribution of responses to the IPA RECOVR questions measuring food insecurity. Approximately 20% of households were classified as food insecure (Table 1).

Bivariate analysis

Bivariate analysis suggested a positive but not statistically significant relationship between water insecurity (T2) and CESD-

10 score during the COVID-19 pandemic (T3) (β : 0.14; 95% CI: -0.02, 0.31; $P = 0.094$) (Table 4). The relationship between food insecurity and CESD-10 score was also positive and statistically significant (β : 1.66; 95% CI: 0.65, 2.66; $P = 0.001$) (Table 3). Joint insecurity had a stronger, statistically significant, and positive relationship with CESD-10 score (β : 2.37; 95% CI: 0.71, 4.07; $P = 0.005$) (Table 3).

In other bivariate analyses, depression before the COVID-19 pandemic (T1) (β : 2.70; 95% CI: 0.15, 0.40; $P < 0.001$) and financial satisfaction (T3) (β : -0.17; 95% CI: -0.33, -0.01; $P = 0.004$) displayed a statistically significant association with depression during the pandemic (T3). Other covariates were not significantly associated with CESD-10 score at T3 (Table 3).

Multivariate analysis

Table 4 shows the results of multivariate regressions with the predictor variables (food insecurity, water insecurity, and joint food and water insecurity) and T3 CESD-10 score. See Supplementary Figure 4 for each of the models mapped against the Directed Acyclic Graph presented earlier in the article.

Water insecurity

A model with the full analytic sample ($n = 323$) and adjusted for wealth, disability, financial satisfaction, and clustering at the settlement level indicated that water insecurity was positively associated with T3 CESD-10 score, although the result was not statistically significant (β : 0.13; 95% CI: -0.01, 0.26; $P = 0.07$). In models that additionally adjusted for CESD-10 score at T1 ($n = 221$), results were similar (β : 0.12; 95% CI: -0.06, 0.30; $P = 0.19$). Removing wealth as a covariate had no change on the effect of water insecurity on CESD-10 score (β : 0.12; 95% CI: -0.06, 0.3; $P = 0.19$). In a sensitivity analysis that was conducted using HWISE data from T3 to check for consistency in association across dry and rainy seasons, the association was stronger and statistically significant (β : 0.35; 95% CI: 0.16, 0.55; $P = 0.001$).

Food insecurity

Before adjusting for CESD-10 score at T1, a model ($n = 320$) adjusted for wealth, disability, financial satisfaction, clustering, and fixed effects at the settlement level indicated a statistically significant, positive relationship between food insecurity and CESD-10 score (β : 1.48; 95% CI: 0.79, 2.17; $P < 0.001$). However, in the subanalysis ($n = 218$) adjusting for CESD-10 score at T1, the relationship between food insecurity and CESD-10 score was attenuated and no longer statistically significant (β : 0.95,

TABLE 3

Bivariate analysis of the CESD-10 score during the COVID-19 pandemic of women living in urban informal settlements in Makassar, Indonesia with resource insecurity and sociodemographic characteristics ($N = 323$)

Variable	Water insecurity (T2)	Food insecurity (T2) ¹	Joint insecurity (T2) ²	Prepandemic CESD-10 score (T1) ³	Wealth (T0)	Disability (T2)	Financial satisfaction (T3)
n	323	320	320	221	323	323	323
β	0.14	1.66	2.37	0.27	-0.09	1.57	-0.17
95% CI	-0.02 to 0.31	0.65–2.66	0.71–4.07	0.15–0.4	-0.3 to 0.11	-0.53 to 3.67	-0.33 to -0.01
P value	0.094	0.001	0.005	<0.001	0.381	0.143	0.004

CESD-10, Center for Epidemiological Studies on Depression Scale, 10 item version; HWISE, Household Water Insecurity Experiences

¹ 3 (0.93%) missing from food insecurity

² 3 (0.93%) missing from joint insecurity

³ 102 (31.58%) missing from CESD-10 score prepandemic

TABLE 4

Multivariate regression results with predictors (water insecurity, food insecurity, and joint food and water insecurity) and the CESD-10 score of women living in urban informal settlements in Makassar, Indonesia during the COVID-19 pandemic

Predictor	Water insecurity ¹			
Model	Adjusted for wealth, disability, and financial situation	Adjusted for all covariates (including CESD-10 score before pandemic)	Adjusted for all covariates without wealth	Sensitivity analysis using T3 HWISE as predictor
<i>n</i>	323	221	221	221
β	0.13	0.12	0.12	0.35
95% CI	−0.01 to 0.26	−0.06 to 0.3	−0.06 to 0.3	0.16–0.55
<i>P</i> value	0.07	0.186	0.19	0.001
Predictor	Food insecurity ^{1,2}			
Model	Adjusted for wealth, disability, and financial situation	Adjusted for all covariates (including CESD-10 score prepandemic)	Adjusted for all covariates without wealth	
<i>n</i>	320	218	218	
β	1.48	0.95	0.96	
95% CI	0.79–2.17	−0.37 to 2.26	−0.3 to 2.22	
<i>P</i> value	0.00	0.157	0.137	
Predictor	Joint food and water insecurity ^{1,3}			
Model	Adjusted for wealth, disability, and financial situation	Adjusted for all covariates (including CESD-10 score prepandemic)	Adjusted for all covariates without wealth	
<i>n</i>	320	218	218	
β	2.4	1.96	1.97	
95% CI	1.43–3.38	0.78–3.15	0.8–3.14	
<i>P</i> value	0.000	0.001	0.001	

CESD-10, Center for Epidemiological Studies on Depression Scale, 10 item version; HWISE, Household Water Insecurity Experiences

¹ 102 (31.58%) missing from CESD-10 score before pandemic

² 3 (0.93%) missing from food insecurity

³ 3 (0.93%) missing from joint insecurity

95% CI: −0.37, 2.26; $P = 0.16$). As with water insecurity, a sensitivity analysis excluding wealth as a covariate did not result in a meaningful change on the effect of food insecurity on depression (β : 0.96; 95% CI: −0.3, 2.22; $P = 0.14$).

Joint food and water insecurity

A model, including all covariates (wealth, disability, and financial satisfaction) with clustering and fixed effects at the settlement level showed a statistically significant, positive relationship between joint food and water insecurity and CESD-10 score (β : 2.40; 95% CI: 1.43, 3.38; $P < 0.001$). When adjusting for CESD-10 score at T1, joint insecurity maintained strong and statistically significant associations with CESD-10 score during COVID-19 (β : 1.96; 95% CI: 0.78, 3.15; $P = 0.001$). A sensitivity analysis removing wealth score from the regression had no influence on the effects of joint resource insecurity on depression (β : 1.97; 95% CI: 0.8, 3.14; $P = 0.001$).

Discussion

In line with our hypothesis, we observed positive associations between household water and food insecurity and self-reported depression score among women living in urban informal settlements during the COVID-19 pandemic in Makassar, Indonesia, with the strongest associations being between joint food and water insecurity and depression score. When analyzed together, the effects of both food and water insecurities together had a strong and statistically significant relationship that was not additive, but rather multiplicative in its association with depression—nearly double what would have been the additive effect. These results corroborate with previous research that suggests joint food and water insecurity compound the individual effects of one or the other [13, 51].

Before adjusting for prepandemic depression score, food insecurity had statistically significant associations with CESD-10 score. However, after adjusting for prepandemic depression, this relationship was still positive but was no longer statistically significant. One possible explanation for this is that individuals facing food insecurity during the COVID-19 pandemic may have been at a heightened risk for, or already facing, food insecurity before the pandemic; therefore, the mental health impacts of resource insecurity already existed. However, because there is no prepandemic data available in RISE for food insecurity or HWISE score, it was not possible to test this hypothesis. It is also possible that residents dealt with food insecurity in ways that were not captured through the 2 IPA RECOVR questions. For example, other measurements of food insecurity, such as feelings of uncertainty or anxiety over accessing food, resorting to socially unacceptable means to obtain food, or reducing food quality were not used [52].

In the primary analysis, water insecurity at T2 had positive (but not statistically significant) associations with CESD-10 score both before and after adjusting for prepandemic depression, which contradicts some of the literature that finds significant associations between water insecurity and mental health in LMICs [53, 54]. To our knowledge, ours is only the second study on depression and water insecurity in LMICs that uses CESD-10 score as a measurement for depression [54, 55], which may be an explanation for the deviation in findings. However, research has shown that seasonality, specifically in regards to differing amounts of rainfall during different seasons, affects water insecurity in both Makassar as well as globally [56–58], thus the timing of data collection may have influenced the outcome. HWISE score was collected during the dry season (T2) in Makassar, whereas the CESD-10 score was collected during the rainy season (T3). The effect of seasonality may have been reflected in

the result of the sensitivity analysis that used HWISE score during T3 as the primary predictor, in which the association was stronger and became statistically significant. Furthermore, although approximately 20% of respondents in our sample were classified as water insecure at T2, >60% reported no experiences of water insecurity at all (i.e., HWISE scores equal to 0) in the past month. It is possible that the distribution of these results may have made it challenging to detect a relationship between water insecurity and CESD-10 score in the main analysis.

Strengths and limitations

Strengths of our study include the novel setting in which the research was conducted, data collection on both food and water insecurity, and use of longitudinal cohort data on depression from time points before and during the COVID-19 pandemic. However, the longitudinal study design also presents a limitation: in approximately one-third of the respondent households, a different household member had responded to survey questions at T1 that means no baseline depression data for the T3 respondent was available. Another limitation was the lack of data on water or food insecurity at T1 that made it impossible to assess any changes in resource insecurity arising from the COVID-19 pandemic and to measure the effect of prepandemic or postpandemic changes to resource insecurity on depression.

Another strength of our study was the use of validated tools in the form of the CESD-10 and the HWISE short form. The IPA RECOVR scale, although used in many countries, has not validated for the measurement of food insecurity [1]. Using a validated food insecurity scale, such as the Household Food Insecurity Access Scale, may present a stronger case [52]. Furthermore, the HWISE-4 scale, being a short version [44], does not provide as much detail as the full HWISE scale and only provides data on household, rather than individual, experiences [44]. Finally, the cluster-randomized design of the RISE trial requires consideration of clustered effects in data analysis, yet the small number of clusters may be problematic for statistical power, and therefore clustering at the settlement level may have obscured the effects of food and water insecurity on depression [60]. The sample size in RISE was predetermined by the number of households in the settlements and calculated to detect an effect on the trial's primary health outcomes assessed in children aged <5 y rather than the outcomes assessed here [30].

Implications for research and practice

Our findings have important implications for policymakers, researchers, and practitioners focused on global health, mental health, urban planning, resilience, and other areas related to urban informal settlements or at the nexus of gender equity, food insecurity, water insecurity, and health or development. Globally, poor mental health is associated with premature mortality and hinders social progress, human capital, and individual potential [61, 62]. As the body of evidence suggesting causal associations between resource insecurity and depression continues to grow [54, 63], understanding these pathways among women and in urban informal settlements, where data are scant, may be particularly important as informal settlements continue to play a pivotal role in urbanization [28]. Future research may also investigate whether resource insecurity in such settings leads to syndemic effects in the form of multiple co-occurring adverse health outcomes, in addition to or beyond depression [55].

The COVID-19 pandemic highlighted mental health disparities globally, and Indonesia was no exception. Indonesian mental health researchers and practitioners found higher reports of poor mental health, including depression [64, 65], and advocates made a call for action regarding increased mental health services and systems strengthening [66]. However, mental health remains a taboo topic in Indonesia, often preventing those who need it from seeking treatment [67]. Women's access to health care, including for mental health, is particularly limited in informal settlements [10]. As a result, those who are impacted most by social, economic, and political stressors may find themselves without the mental health support or treatment needed to ensure their well-being.

The findings of this study underline the importance of addressing food and water insecurity together, rather than in silos as is standard practice, particularly as they relate to women's mental health and well-being. Coordination between the water, sanitation and hygiene (WASH) and nutrition sectors may be vital for delivering effective programs that reflect the complexity of their target populations' lived experiences [68], and, when approached through a gendered lens, can help in achieving SDGs 5 and 6, which focus on women's equity and access to resources [69]. In urban informal settlements, where there may be both limited or inconsistent access to WASH infrastructure and disrupted food environments/food supply chains [24], such coordination can additionally contribute to the achievement of SDG 11, sustainable cities and communities. To our knowledge, there are currently no policies, programs or interventions that jointly address water and food insecurity directly as primary outcomes [70]. Cross-sectoral collaboration and mainstreaming of gender across mental health, nutrition, WASH, and economic development could be vital in a larger, more sustainable mental health response, to 'build back better' for the benefit of women in urban informal settlements in LMICs.

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IC, SS, AS, and RS: designed the research; IC conducted research, analyzed the data and wrote the paper; IC, SS, and AS: had primary responsibility for the final content; IC, SS, AS, RS,

BB, NF, SN, and RT: all played a primary role in project administration; SS and AS: provided supervision over the course of the research activity; IC, RS, BB, TC, SN, and RT: supported the interpretation of the research; and all authors critically reviewed the manuscript, provided feedback, and read and approved the final manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://doi.org/10.1016/j.tjnnt.2023.01.010>.

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