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Intersecting Trajectories of Food Insecurity and Social Network Vulnerability Across Mid- and Later Life: Associations with Health and Healthcare Utilization in Indonesia

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Abstract

Background

Food insecurity and weakening social networks are intersecting determinants of healthy aging, particularly in LMICs undergoing rapid demographic and socioeconomic transitions. How concurrent declines in these domains shape health and healthcare utilization trajectories in mid- and later life remain understudied.

Methods

Using longitudinal data from 6,786 adults aged ≥ 40 years from waves 4 (2007/08) and 5 (2014/15) of the Indonesian Family Life Survey, this study adopts a longitudinal outcome-wide analysis and examines how combined trajectories of food insecurity and social network change are associated with a wide range of physical, mental, cognitive, functional, and healthcare utilization outcomes.

Results

In adjusted models, food-insecure individuals had higher odds of being overweight across groups, with the strongest associations observed among those experiencing both food insecurity and vulnerable social networks. This doubly exposed group also had higher odds of loneliness and significantly lower healthcare utilization. Notably, food insecurity remained associated with elevated depressive symptoms even among those with protective social networks. These findings highlight the compounded effects of material and relational disadvantage in shaping ageing-related health risks.

Conclusions

Food insecurity in mid- and later life is not only a question of access to food, but also of the social conditions that enable individuals to cope, maintain well-being, and engage with care systems. Policies aiming to support healthy ageing in LMICs should therefore move beyond a narrow focus on food provision to include strengthening social infrastructures, addressing social isolation, and integrating routine screening for food insecurity and relational vulnerability within community-based healthcare systems.

1. Introduction

Food insecurity is a critical global challenge with profound implications for physical and mental health across the life course and in diverse population groups [1], [2]. Within the broader public health landscape, however, food insecurity among individuals in mid- and later adulthood has received comparatively less attention (Pranoto et al., *forthcoming*), than other demographic groups such as children and mothers [3], [4]. This gap is particularly notable given the rapid demographic transition occurring worldwide, especially in low- and middle-income countries (LMICs), which are projected to host nearly 80% of the world's older population by 2030 [5].

Evidence from high-income countries consistently shows that food insecurity in mid- and later life is associated with adverse health outcomes, including higher non-communicable disease (NCD) morbidity [6], [7] and

multimorbidity [8], as well as elevated risks of premature mortality [9], cognitive impairment [10], mental health problems [11], and inequitable patterns of healthcare utilization [12]. These risks may be amplified in older populations due to age-related declines and structural socioeconomic constraints that limit access to adequate nutrition, healthcare, and social protection [1], [13]. Food insecurity can exacerbate chronic disease and hinder effective disease management [14], indicating that it functions not only as a form of material deprivation but also as a psychosocial stressor within broader processes of social vulnerability. Its negative health effects arise not only from insufficient food access, but also from the ongoing stress and insecurity produced by structural social inequalities [15].

Although the literature linking food insecurity to health outcomes is expanding, longitudinal evidence, especially examining how transitions in food insecurity status across the life course shape health, remains limited [16]. Most transition-focused studies have been conducted among children, showing that movements into or out of food insecurity influence physical health, behavioral outcomes, and overall development [17], [18]. These findings underscore that food insecurity is a dynamic and temporally embedded exposure, and that transition patterns carry meaningful consequences; however, comparable evidence for mid- and later adulthood is scarce, representing a substantial gap in research among aging populations. In midlife and older age, food insecurity may emerge, persist, or resolve over time, indicating that these populations are likely to experience distinct food insecurity trajectories with potentially divergent health implications [19]. Mapping and understanding the unfolding of such transitions is therefore critical for capturing heterogeneity in ageing trajectories and for identifying periods of heightened vulnerability or resilience.

Beyond health, food insecurity also has important social implications. Among older adults, it can disrupt social relationships, reduce community participation, and heighten social isolation [20], [21]. Conversely, social networks have been shown to buffer the negative effects of food insecurity by providing emotional support, sharing resources, facilitating access to food, and strengthening engagement with assistance programs [22], [23], [24], [25], [26], [27]. From a social-epidemiological perspective, social networks constitute a key relational resource that shapes individual's exposure to, and capacity to cope with, material hardship, yet they may themselves be eroded under conditions of sustained deprivation [28], [29], [30]. In this sense, food insecurity and social networks are dynamically interrelated, with material scarcity potentially undermining social ties, and weakened networks in turn exacerbating vulnerability to food insecurity.

Despite this relevance, the intersection between food insecurity, social networks, and health outcomes in mid- and later adulthood, particularly in LMIC contexts, remains understudied. Food insecurity and social networks are each well-established determinants of health and well-being especially among aging populations (Pranoto et al., *forthcoming*). Yet they are seldom examined jointly, despite the likelihood that they intersect and cluster along social gradients of vulnerability and disadvantage. Individuals experiencing food insecurity may also have declining social networks, either as a cause or a consequence, thereby compounding disadvantage through mutually reinforcing material and relational mechanisms [31]. Conversely, strong and diverse social networks may buffer individuals from the detrimental effects of food insecurity [32]. Taken together, this suggests that food insecurity and social networks should be understood as intersecting and dynamic dimensions of social vulnerability, constituting two axes along which disadvantage may accumulate or be buffered over time. Understanding how these dimensions of disadvantage intersect is central to social epidemiological debates of cumulative risk, social vulnerability, and unequal ageing [33]. This is particularly relevant in middle-income contexts undergoing rapid nutritional, social, and demographic transitions, such as Indonesia.

Indonesia, Southeast Asia's most populous nation and the world's fourth most populous country, is rapidly aging while continuing to experience a considerable burden of food insecurity and health challenges [34], [35]. National-level evidence on food insecurity in midlife and older age, especially on its longitudinal health impacts and its interaction with broader social and relational determinants, remains scarce. The Indonesian Family Life Survey (IFLS), with over two decades of rich demographic, socioeconomic, health, and social network data, offers a unique opportunity to address these gaps [36], [37].

Against this background, this study adopts an intersectional life-course perspective to examine how joint trajectories of food insecurity and social network change shape the health and healthcare use among adults in mid- and later life in Indonesia. Specifically, we examine how joint trajectories of food insecurity and social network change between 2007/08 and 2014/15 and their associations with physical, mental, cognitive, functional, and healthcare utilization outcomes. By identifying distinct joint exposure patterns, this study seeks to capture how material and relational vulnerabilities co-evolve and interact over time, potentially introducing compounded risks or protective effects in mid- and later life.

2. Methods

2.1 Study design and analytical approach

This study adopts a longitudinal outcome-wide analysis to examine the joint associations between food insecurity trajectories and social network change and a range of health and healthcare-related outcomes among adults aged 40 years and older at baseline in Indonesia. Drawing on a life course perspective, this study examines how dynamic transitions in food insecurity and social network composition between 2007/08 and 2014/15 shape health and healthcare outcomes. By modelling exposure trajectories, rather than static states, we capture the cumulative and interactive effects of material and relational disadvantage over time. This temporal sequencing allows us to conceptualize food insecurity and social network change as critical turning points that may set individuals on diverging health trajectories in mid- and later life. Such an approach aligns with pathway and cumulative risk models central to life course epidemiology [38].

2.2 Data Source

Data are drawn from two waves of the IFLS, a longitudinal multipurpose survey conducted in Indonesia since 1993 [36], [37]. The IFLS employs a stratified sampling design and is representative of approximately 83% of the Indonesian population, making it one of the most comprehensive and longest-running population-based panel surveys in an LMIC setting. For this study, we use IFLS-4 and IFLS-5, which were fielded in 2007-08 and 2014-15, respectively, providing a seven-year observation window. The study period coincides with a phase of rapid social and demographic change in Indonesia, including population aging, shifts in household structures, and continued economic and nutritional transitions, providing relevant context for examining changes in food insecurity and social networks over time [39], [40]. To the best of our knowledge, this database represents the most comprehensive source available within the Indonesian context. Although the data were collected some time ago, they remain highly relevant for addressing the specific objectives of this study. The IFLS are public-use data and are available through the RAND Corporation upon registration (www.rand.org/labor/FLS/IFLS). Ethical approval for IFLS-4 and IFLS-5 was obtained by RAND, SurveyMeter, and Gadjah Mada University, and all participants provided informed consent.

2.3 *Measures*

2.3.1 Food insecurity

Food insecurity was measured using the World Food Programme's Food Consumption Score (FCS) indicator [41], [42]. The IFLS includes a food frequency questionnaire that captures the number of days respondents consumed specific food items during the previous seven days. Items were grouped into five food categories: staples, vegetables, fruits, protein-rich foods, and dairy, and then weighted according to their relative nutritional value to construct the FCS. The FCS categories were defined as: poor (< 21), borderline (21–35), and acceptable (> 35). Following WFP standards, respondents in the poor or borderline categories were classified as food insecure, while those in the acceptable category were classified as food secure. Food insecurity transitions between IFLS-4 and IFLS-5 were first operationalized into four categories: persistently food secure, transitioned into food security, transitioned into food insecurity, and persistently food insecure. For the purpose of constructing joint exposure groups (Section 2.3.3), these transition categories were subsequently collapsed into a binary food insecurity status, distinguishing food secure (persistently food secure or transitioned into food security) from food insecure (persistently food insecure or transitioned into food insecurity).

2.3.2 Social networks

Social networks were operationalized using a composite Social Network Index (SNI) constructed longitudinally using information from both survey waves. The index captures the diversity and breadth of social ties, including family and non-family contacts, community engagement, and participation in social organizations [43]. The index was constructed by integrating information on the presence and frequency of social interactions within each domain. For each domain, respondents were assigned a score indicating whether they reported active engagement or regular contact. Domain-specific scores were then summed to generate a composite SNI score, with higher values reflecting greater social network diversity and broader social integration. For analytical purposes, the composite SNI was dichotomized into weak versus strong social networks at each wave. Changes in social networks between IFLS-4 and IFLS-5 were then assessed to construct a social network transition variable, distinguishing respondents with maintained or improving social networks from those experiencing persistently weak or declining social network diversity over time. This two-wave comparison operationalizes social networks as dynamic relational exposure across mid- and later adulthood, reflecting dimensions of relational protection versus vulnerability. For the purpose of constructing joint exposure groups, these SNI transition categories were subsequently collapsed into a binary SNI transition status, distinguishing protective (maintained or improved SN) from vulnerable (persistently weak or improving).

2.3.3 Joint Food Insecurity–Social Network exposure groups

To capture the intersection of material and relational conditions in mid- and later life, we constructed a joint exposure variable combining food insecurity status and social network change between IFLS-4 (2007/08) and IFLS-5 (2014/15). Food insecurity was classified as food secure (FS) or food insecure (FI) based on transitions across waves (Section 2.2.1), while social networks (SN) were classified as protective or vulnerable based on changes in the SNI between waves (Section 2.2.2). This resulted in four joint FI-SN transition groups: (i) FS + protective SN; (ii) FS + vulnerable SN; (iii) FI + protective SN; and (iv) FI + vulnerable SN.

This joint exposure operationalization reflects a life-course perspective in which material and relational vulnerabilities may intersect, co-occur, or diverge over time, potentially producing compounded risks or protective effects on health. and may cluster to produce compounded or protective effects on health outcomes. The FI-SN joint variable was used as the main exposure in the longitudinal outcome-wide analyses, enabling a

comprehensive assessment of how intersecting trajectories of food insecurity and social network change shape health and healthcare-related outcomes among Indonesian adults in mid- and later life.

2.3.4 Health and healthcare-related outcomes

Health outcomes in IFLS-5 (2014/15) were examined using an outcome-wide epidemiological framework [44] and included ten outcomes clustered into physical, mental, cognitive, functional, and healthcare-related domains, as shown in Table 1.

Table 1
Summary of measurement and operationalization of health and healthcare-related outcomes in IFLS-5.

Outcomes	Measurement	Operationalization
Physical health:		
Blood pressure (BP)	BP was measured in the field by trained staff using an automated oscillometric monitor. The average of three seated measurements was used to define systolic and diastolic BP in mmHg and self-reported use of antihypertensive medication.	0 = Hypertension (defined as mean systolic BP ≥ 140 mmHg and/or mean diastolic BP ≥ 90 mmHg and/or current use of antihypertensive medication) [1] 1 = Normotensive
Body mass index (BMI)	Height and weight were measured during the household visit and BMI calculated as kg/m². BMI was categorized using WHO/Asian) cut-points[2].	0 = Obese (BMI > 27.50) 1 = Overweight (23.00–27.49) 2 = Normal weight (18.50–22.99) 3 = Underweight (< 18.48)
Non communicable disease (NCD) morbidity	NCD morbidity was defined based on self-reported medical diagnosis of any one condition, including asthma, other chronic lung diseases, cancer or malignant tumors, diabetes or high blood sugar, cardiovascular diseases (heart attacks, coronary heart diseases, angina, other heart problems) or stroke.	0 = Any NCD 1 = None
Mental health:		
Depressive symptoms	Depressive symptoms were assessed using the 10-item Center for Epidemiologic Studies Depression scale (CES-D-10)[3]. Item scores were summed to produce a total score; a cut-off of ≥ 10 was used to indicate depressive symptoms.	0 = Yes 1 = No
Loneliness	Loneliness was assessed using a single-item measure from the positive and negative affect questionnaire in IFLS-5. Responses to the question "Yesterday, did you feel lonely?" were recorded on a five-point scale. Loneliness was operationalized as a binary outcome, with respondents reporting feelings greater than "a little" classified as lonely.	0 = Yes 1 = No
Self-rated health (SRH)	SRH was assessed using a five-point scale ranging from very healthy to very unhealthy. Responses were collapsed into good (very healthy, somewhat healthy, average) and poor (somewhat unhealthy, very unhealthy).	0 = Poor 1 = Good
Cognitive health:		
Fluid cognitive performance	Fluid cognitive performance was assessed using an abridged version of Raven's Progressive Matrices, a non-verbal, self-paced test of fluid intelligence administered in the IFLS. The test comprised eight items, and the total number of correct responses was summed to generate a composite fluid intelligence score. For analytical	0 = Low 1 = Higher

Outcomes	Measurement	Operationalization
Physical health:		
	purposes, fluid cognitive performance was operationalized as a binary outcome distinguishing respondents in the lowest quartile of the score distribution from those in the upper three quartiles.	
Functional health:		
Activities of Daily Living (ADL)	Basic functional ability was assessed using five ADL items, capturing respondents' ability to perform core self-care tasks such as bathing, dressing, eating, and toileting[5]. Respondents reported whether they experienced difficulty performing each activity. ADL limitation was operationalized as a binary outcome, with respondents classified as having an ADL limitation if they reported difficulty in at least one ADL item, and as independent if they reported no difficulty in any item.	0 = Any limitation (dependent) 1 = No limitation (independent)
Instrumental Activities of Daily Living (IADL)	Higher-order functional ability was assessed using six IADL items, reflecting more complex daily activities such as shopping, preparing meals, managing money, and using transportation. Respondents reported whether they experienced difficulty performing each activity. IADL limitation was operationalized as a binary outcome, with respondents classified as having an IADL limitation if they reported difficulty in at least one IADL item, and as independent otherwise.	0 = Any limitation (dependent) 1 = No limitation (independent)
Healthcare utilization:		
Any healthcare utilization	Healthcare utilization included any outpatient visit in the past four weeks or inpatient admission in the past 12 months. Utilization was dichotomized as any versus none.	0 = Any healthcare utilization 1 = No healthcare utilization

[1] Hypertension definition adapted from WHO Expert Committee on Hypertension Control. Hypertension control. Geneva: World Health

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instrumental activities of daily living. The Gerontologist, 9 (3), 179–186

2.3.5 Covariates

Analyses were adjusted for potential confounders measured at baseline (IFLS-4), including sex, age group, education level, socioeconomic status, and area of residence. Sex was coded as men and women. Age was categorized into 10-year age groups (40–49, 50–59, 60–69, and 70 years and older). Education level was classified into no formal schooling, elementary education, high school education, and university education. Socioeconomic status was operationalized using quartiles of monthly household per capita expenditure (PCE), with the first quartile representing the poorest 25% of the sample. PCE was pre-calculated by the IFLS based on total monthly household expenditures on food and non-food consumption, including purchased goods, services, durables, housing, and education-related expenditures, expressed in Indonesian Rupiah and divided by the number of household members [36]. The area of residence was classified as rural or urban.

2.4 Statistical analyses

All analyses were conducted using Stata version 14. We first described sample characteristics across the four joint FI-SN exposure groups using descriptive statistics. Differences in sociodemographic characteristics across exposure groups were assessed to examine patterns of material and relational vulnerability in the study population. We then used logistic regression models to examine associations between the joint exposure groups and a range of binary health and healthcare outcomes across the five outcome domains assessed in IFLS-5. For BMI, which was categorized into four groups based on Asian-specific cutoffs, we used an ordered logistic regression model. All models were adjusted for potential confounders, including sex, age group, education level, socioeconomic status, and area of residence. The most advantaged exposure group (FS + protective SN) was used as the reference category. This analytical approach follows an outcome-wide epidemiological framework, allowing for a systematic assessment of how intersecting trajectories of food insecurity and social network vulnerability are associated with multiple health and healthcare outcomes in mid- and later adulthood. All estimates are reported as odds ratios (OR) with 95% confidence intervals, and a p-value of < 0.05 was considered statistically significant.

2.5 Ethics statement

This study is based on secondary analysis of publicly available data from the Indonesian Family Life Survey (IFLS). The IFLS was conducted by the RAND Corporation in collaboration with SurveyMETER and Gadjah Mada University. Ethical approval for data collection was obtained from relevant institutional review boards, and all participants provided written informed consent prior to participation. The present study did not involve direct contact with human subjects and used anonymized data; therefore, no additional ethical approval was required. The study was conducted in accordance with established ethical principles for research involving human participants.

3. Results

3.1 Study sample and distribution of the joint FI-SN exposures

A total of 6,786 respondents from IFLS-4 and IFLS-5 were included in the analysis. Table 2 presents the characteristics of the total sample and stratifies respondents across the joint FI-SN exposure groups. Overall, the sample comprised individuals in mid- and later adulthood, with the majority aged 40–59 years (82.9%) at baseline, slightly more women than men (53.7%), and over half having completed elementary education or less

(67.0%). Across the full spectrum of physical, mental, cognitive, functional and healthcare-related outcomes, all indicators were prevalent in the sample, ranging from a low prevalence of high blood pressure (3.9%) to over one quarter reporting depressive symptoms (25.7%). Only one third of respondents were of normal weight, and just over one quarter demonstrated above-average fluid cognitive performance, while more than three quarters reported healthcare utilization in the past year. Across the four joint FI-SN exposure groups, the largest group was food secure with vulnerable social networks (45,7%), followed by the group who is food insecure with vulnerable social networks (24.1%) and food secure with protective social networks (20%). The smallest group comprised individuals who were food insecure but with protective social networks (10.2%) (Fig. 1). The four groups differed significantly in their demographic and socioeconomic composition as well as across most health and healthcare-related outcomes, except for depressive symptoms, self-rated health, and ADL limitations (Table 2).

Table 2
Sample characteristics stratified by joint FI-SN exposure groups (N = 6,786).

Variables	Total sample 6786 (100%)		Joint FI-SN exposure groups								
	n	%	FS + protective SN 1360 (20.04%)		FS + vulnerable SN 3099 (45.67%)		FI + protective SN 689 (10.15%)		FI + vulnerable SN 1638 (24.14%)		p-value
Age Groups											
60+	1163	17.14	151	2.23	523	7.71	107	1.58	382	5.635	< 0.001
50–59	2099	30.93	329	4.85	1058	15.59	147	2.17	565	8.33	
40–49	3524	51.93	880	12.97	1518	22.37	435	6.41	691	10.18	
Sex											
Men	3144	46.33	454	6.69	1611	23.74	225	3.32	854	12.58	< 0.001
Women	3642	53.67	906	13.35	1488	21.93	464	6.84	784	11.55	
Education											
No schooling	951	14.01	156	2.30	377	5.56	118	1.74	300	4.42	< 0.001
Elementary school	3635	53.57	721	10.62	1658	24.43	361	5.32	895	13.19	
High school	1704	25.11	372	5.48	816	12.02	161	2.37	355	5.23	
University	496	7.31	111	1.64	248	3.65	49	0.72	88	1.30	
Socioeconomic status											
1st quartile (poorest)	1628	23.99	296	4.36	649	9.56	218	3.21	465	6.85	< 0.001
2nd quartile	1698	25.02	308	4.54	783	11.54	162	2.39	445	6.56	
3rd quartile	1740	25.64	353	5.20	827	12.19	150	2.21	410	6.04	
4th quartile	1720	25.35	403	5.94	840	12.38	159	2.34	318	4.69	
Place of residence											
Rural area	3525	51.95	641	9.45	1570	23.14	370	5.45	944	13.91	< 0.001
Urban area	3261	48.05	719	10.60	1529	22.53	319	4.70	694	10.23	
Blood pressure											
Hypertensive	261	3.85	55	0.81	134	1.97	30	0.44	42	0.62	0.020

Variables	Total sample 6786 (100%)		Joint FI-SN exposure groups								
	n	%	FS + protective SN 1360 (20.04%)		FS + vulnerable SN 3099 (45.67%)		FI + protective SN 689 (10.15%)		FI + vulnerable SN 1638 (24.14%)		p-value
Age Groups											
Normotensive	6525	96.15	1305	19.23	2965	43.69	659	9.71	1596	23.52	
Body mass index											
Obese	1295	19.08	340	0.26	586	8.64	133	1.96	236	3.48	< 0.001
Overweight	2515	37.06	545	0.22	1154	17.01	250	3.68	566	8.34	
Normal weight	2198	32.39	381	0.17	1009	14.87	220	3.24	588	8.66	
Underweight	778	11.46	94	0.12	350	5.16	86	1.27	248	3.65	
NCD morbidity											
Any	977	14.40	193	2.84	484	7.13	93	1.37	207	3.05	0.039
None	5809	85.60	1167	17.20	2615	38.54	596	8.78	1431	21.09	
Depressive symptoms											
No depressive symptoms	5045	74.34	1026	15.12	2319	34.17	488	7.19	1212	17.86	0.121
Depressive symptoms	1741	25.66	334	4.92	780	11.49	201	2.96	426	6.28	
Loneliness											
Not lonely	5681	83.72	1149	16.93	2626	38.70	575	8.47	1331	19.61	0.017
Lonely	1105	16.28	211	3.11	473	6.97	114	1.68	307	4.52	
Self-rated health											
Poor	1087	16.02	214	3.15	481	7.09	109	1.61	283	4.17	0.457
Good	5699	83.98	1146	16.89	2618	38.58	580	8.55	1355	19.97	
ADLs											
Any limitations	666	9.81	118	1.74	298	4.39	76	1.12	174	2.56	0.213
No limitation	6120	90.19	1242	18.30	2801	41.28	613	9.03	1464	21.57	
IADLs											

Variables	Total sample 6786 (100%)		Joint FI-SN exposure groups								
	n	%	FS + protective SN 1360 (20.04%)		FS + vulnerable SN 3099 (45.67%)		FI + protective SN 689 (10.15%)		FI + vulnerable SN 1638 (24.14%)		p-value
Age Groups											
Any limitation	904	13.32	145	2.14	426	6.28	88	1.30	245	3.61	0.005
No limitations	5883	86.69	1215	17.90	2673	39.39	601	8.86	1393	20.53	
Fluid cognitive performance											
Low performance	5400	79.58	1056	15.56	2432	35.84	558	8.22	1354	19.95	0.001
Higher performance	1386	20.42	304	4.48	667	9.83	131	1.93	284	4.19	
Healthcare utilization											
Any	5130	75.60	997	14.69	2316	34.13	524	7.72	1293	19.05	0.002
None	1656	24.40	363	5.35	783	11.54	165	2.43	345	5.08	

3.2 Prevalence and transitions in food insecurity and social networks

Between 2007/08 and 2014/15, the prevalence of food insecurity increased from 22.2% to 34.3%. The majority of respondents remained persistently food secure over the two waves (52.5%), followed by those who transitioned into food insecurity (25.3%), those who transitioned into food security (13.3%), and those who were persistently food insecure (8.9%). Over the same period, substantial changes were observed in social networks. The proportion of respondents characterized by vulnerable social networks increased markedly from 60.8% in wave 4 to 87.9% in wave 5. This pattern reflected in the distribution of social network trajectories: the largest group experienced a decline in social networks (69.8%), followed by those who remained persistently weak (15.4%). Smaller proportions showed improvements in social networks (10.3%) or remained persistently strong over time (4.5%). Figure 1 presents Sankey diagrams illustrating the group distributions and transitions in food insecurity and social network status between the two waves, highlighting the dynamic nature of both material and relational conditions in this mid- and later adulthood sample.

3.3 Associations between joint FI–SN exposure and health and healthcare-related outcomes

Table 3 presents the adjusted odds ratios (ORs), 95% confidence intervals (CIs), and p-values for associations between the joint FI-SN exposure groups and health and healthcare-related outcomes. Across physical health

outcomes, all food-insecure (FI) exposure groups showed higher odds of overweight compared with the food secure with protective social networks reference group, with the strongest association observed for the FI + vulnerable SN group (OR = 1.25, 95% CI 1.03–1.52, $p < 0.05$). Although elevated odds of NCD morbidity and high blood pressure were observed in the FI + vulnerable SN group, these associations did not reach statistical significance. For mental health outcomes, FI + protective SN was associated with higher odds of depressive symptoms (OR = 1.23, 95% CI 1.00–1.52, $p < 0.05$), while FI + vulnerable SN was associated with higher odds of loneliness (OR = 1.22, 95% CI 1.00–1.49, $p < 0.05$). No significant differences were observed for self-rated health.

No statistically significant differences were observed across groups for functional health outcomes, including ADLs and IADLs. Similarly, cognitive outcomes showed no significant differences, although FI-exposed groups tended to have lower odds for above-average fluid cognitive performance. In terms of healthcare utilization, respondents in the FI + vulnerable SN group had significantly lower odds of engaging in any inpatient or outpatient care compared with the reference group (OR = 0.80, 95% CI 0.67–0.95, $p < 0.05$), indicating reduced healthcare engagement among those with dual exposure.

Table 3
Adjusted odds ratios (ORs) and 95% confidence intervals (Cis) for the associations between joint FI-SN exposure groups and health and healthcare-related outcomes among adults aged 40 years and older in IFLS (N = 6,786).

Outcomes		OR (95% CI)		
		FS + vulnerable SN	FI + protective SN	FI + vulnerable SN
Physical health	Blood pressure	0.86 (0.62–1.19)	0.88 (0.56–1.39)	1.41 (0.93–2.13)
	Body mass index classifications	1.06 (0.90–1.25)	1.25 (0.99–1.59)	1.25 (1.03–1.52)*
	NCD morbidity	0.88 (0.73–1.06)	0.96 (0.73–1.26)	1.03 (0.82–1.28)
Functional health	ADLs	0.93 (0.74–1.17)	0.80 (0.59–1.09)	0.89 (0.69–1.15)
	IADLs	0.88 (0.72–1.09)	0.90 (0.67–1.20)	0.91 (0.72–1.14)
Cognitive health	Fluid intelligence	0.96 (0.82–1.14)	0.93 (0.73–1.19)	0.90 (0.74–1.09)
Mental health	Depressive symptoms	1.08 (0.93–1.26)	1.23 (1.00-1.52)*	1.11 (0.94–1.32)
	Loneliness	1.01 (0.84–1.20)	1.03 (0.80–1.49)	1.22 (1.00-1.49)*
	Self-Rated Health	0.96 (0.84–1.11)	0.97 (0.80–1.19)	0.99 (0.84–1.16)
Healthcare use	Healthcare utilization	0.98 (0.84–1.14)	0.90 (0.73–1.12)	0.8 (0.67–0.95)*

Reference group are the 'FS + protective SN group

** p < 0.05*

***p < 0.01*

****p < 0.001*

4. Discussion

Our study examined how joint trajectories of food insecurity and social network change shape multiple dimensions of health and healthcare utilization among adults in mid- and later life in Indonesia. Two interrelated contributions emerge. First, food insecurity - particularly when coupled with declining or persistently weak social networks - constitutes a salient risk configuration for unhealthy ageing. Second, both food insecurity and social networks operate as dynamic, time-varying exposures whose intersection generates distinct patterns of risk in mid- and later adulthood. Taken together, we argue that our findings underscore the importance of understanding ageing through the co-evolution of material and relational conditions, rather than treating these as analytically separable domains.

The outcome-wide analysis showed that the most disadvantaged group - those experiencing both food insecurity and vulnerable social networks - had higher odds of overweight, loneliness, and lower healthcare utilization. These outcomes map onto central components of the contemporary burden of disease in ageing populations, particularly in LMICs undergoing rapid epidemiological and nutritional transitions [45], [46]. Overweight and diet-related conditions increasingly coexist with food insecurity, while mental health problems and unmet healthcare needs contribute substantially to disability and reduced quality of life. The co-occurrence of these outcomes within the same exposure group suggests a shared etiological substrate rooted in the conjunction of material scarcity and relational fragility.

The association between food insecurity and overweight aligns with a growing body of evidence on the “double burden” of malnutrition [47], [48], [49]. In this literature, overweight among food-insecure populations is not interpreted as nutritional adequacy but as the consequence of constrained dietary choices, reliance on low-cost energy-dense foods, and cyclical eating patterns associated with uncertainty and scarcity [50], [51], [52], [53]. Empirical studies from Latin America [54], [55] and Asia [56], [57] have consistently documented positive associations between food insecurity and overweight, particularly among women and older adults. In the Indonesian context, where dietary transitions are characterized by increased availability of ultra-processed foods alongside persistent inequalities in access to diverse and nutrient-rich diets, food insecurity is likely to manifest through poor dietary quality rather than caloric insufficiency. This finding reinforces the need to conceptualize food insecurity as a multidimensional exposure encompassing not only access, but also stability, quality, and social meaning [58], [59], [60], [61].

The mental health findings of our study further refine understanding of how material and relational disadvantage shape well-being. Loneliness was most pronounced among those experiencing both food insecurity and vulnerable social networks, indicating a compounded form of deprivation that is simultaneously material and social. This is consistent with studies in both high- and low-income settings showing that the intersection of economic hardship and weak social ties is associated with the highest levels of loneliness and exclusion [62], [63], [64], [65], [66]. Mechanistically, food insecurity may constrain social participation, generate stigma, and disrupt reciprocal exchange, while network erosion reduces opportunities for emotional support and belonging. These processes likely operate synergistically, producing what may be conceptualized as a condition of “double deprivation.”

At the same time, the finding that food insecurity in the presence of protective social networks was associated with depressive symptoms points to limits of social buffering. One interpretation is that social ties do not fully offset the psychosocial stressors associated with material hardship. Individuals embedded in otherwise supportive networks may still experience shame, anxiety, or anticipatory stress related to food insecurity, particularly where norms of reciprocity are strong. Research in LMIC contexts has shown that reliance on others for food can strain relationships and undermine self-worth, even in the presence of available support [67], [68], [69]. These findings suggest partially distinct pathways: food insecurity operating through stress, uncertainty, and perceived inadequacy, and network vulnerability operating through isolation, reduced social integration, and diminished participation. The coexistence of these pathways underscores the need to move beyond single-exposure models in analyses of mental health in later life [70], [71].

The finding that individuals experiencing both food insecurity and vulnerable social networks had lower odds of healthcare utilization is particularly consequential. This pattern should not be interpreted as reduced need, but as a marker of constrained access and unmet need among those facing compounded disadvantage. A substantial

literature demonstrates that social networks facilitate healthcare access by providing financial resources, transport, accompaniment, and navigational support [72], [73]. Where such networks are weak or deteriorating, individuals may lack the practical and emotional resources required to engage with healthcare systems. Importantly, underutilization of care among socially isolated and economically disadvantaged groups has been documented across settings [74], [75]. Individuals with limited social ties are less likely to seek preventive care, adhere to treatment, or engage with health services even when clinically indicated (Van 't Wout, S., et al., *forthcoming*). In the context of food insecurity, competing priorities may further constrain care-seeking behavior: scarce financial resources may be preferentially allocated to food, while fatigue, poor mental health, and reduced agency may limit healthcare engagement. From a social epidemiological perspective, this pattern reflects structural barriers rather than individual choice. The joint exposure of food insecurity and network vulnerability may therefore identify a "hidden high-risk" group characterized by both elevated need and reduced utilization, with important implications for equity in ageing health systems, particularly in LMIC contexts where informal networks remain central to care access.

A key contribution of this study lies in its focus on the dynamic nature of both food insecurity and social networks. More than one quarter of respondents transitioned into food insecurity over the study period, while a smaller proportion transitioned out. This degree of mobility is consistent with longitudinal evidence from LMICs such as India [76], South Africa [77], and Brazil [78], where food insecurity is increasingly understood as episodic and contingent on economic shocks, health events, and changing household structures. In aging populations, such transitions may become more frequent as individuals move in and out of vulnerability in response to declining health, income instability, and shifts in support systems.

These transitions matter because they reflect shifts in vulnerability across the life course. Transitions into food insecurity may constitute critical turning points that redirect health trajectories, while transitions out may signal temporary recovery or resilience. However, most global monitoring systems rely on cross-sectional indicators, thereby obscuring temporal dynamics and cumulative exposure. Our findings therefore support calls for longitudinal measurement frameworks that capture trajectories rather than states. Equally striking was the widespread decline in social network diversity over time. By the end of the observation period, the majority of respondents were characterized by vulnerable networks. While some contraction of social ties is expected with ageing [79], [80], the magnitude observed here suggests the influence of broader structural transformations, including urbanization, migration, and changing norms of intergenerational support. Evidence from both high-income and LMIC settings indicates that networks become smaller and more kin-focused with age, but also potentially more fragile in contexts of socioeconomic change [81], [82], [83].

Conceptually, this study advances a more integrated understanding of food insecurity by bringing together material and relational dimensions of vulnerability. Rather than invoking intersectionality in its canonical sense (i.e., overlapping social identities) [84], the present analysis operationalizes intersecting exposures that produce cumulative and interacting risks. Food insecurity represents material deprivation, while social networks capture relational resources and constraints. Their joint consideration reveals configurations of risk that remain obscured in single-exposure analyses.

This perspective aligns with what we term 'relational approaches in public health'. Conventional food insecurity interventions have focused on access and availability - "putting food on the plate" [85]. In contrast, a relational approach emphasizes the social infrastructures that sustain food security over time - "keeping the plate from going empty". From this perspective, social networks are not merely background social conditions, but active

mechanisms through which food insecurity is prevented, mitigated, or exacerbated. Networks may provide instrumental, informational, and emotional support, buffer gaps in formal welfare and healthcare systems, and shape individuals' capacity to cope with economic and health-related shocks [86]. This framing shifts attention from short-term food provision towards the relational conditions that enable resilience, continuity, and adaptive capacity in later life. However, these networks are themselves unequally distributed and subject to erosion under conditions of sustained strain. Our findings support this relational framing. Protective social networks appear to modify, but not eliminate, the effects of food insecurity, while vulnerable networks amplify its consequences, particularly for loneliness and healthcare access. This suggests that interventions targeting food insecurity should extend beyond individual or household-level provision to include strategies that strengthen relational infrastructures, such as community-based support, social participation, and mechanisms that sustain reciprocity. Such an approach is particularly relevant for ageing populations, where both material and relational resources may be simultaneously declining.

Indonesia provides a particularly relevant context for this analysis. As one of the world's most populous countries, it is undergoing rapid demographic ageing alongside ongoing nutritional and socioeconomic transitions. Informal social networks continue to play a central role in providing support in later life, yet these networks are increasingly under pressure. The high prevalence of social network vulnerability observed in this study suggests that assumptions about stable family-based care may no longer hold. These findings call for a re-examination of "family-default" models of ageing support [87], [88], [89]. Migration, urbanization, and changing household structures may weaken traditional systems of intergenerational care, leaving older adults increasingly reliant on fragile or shrinking networks. The high prevalence of network vulnerability observed here challenges assumptions of stable relational support in later life and highlights the need to consider social networks as dynamic and potentially depleting resources. From a policy perspective, this implies that addressing food insecurity among ageing populations requires attention not only to income and food provision, but also to the relational infrastructures that enable access to resources. Screening for both food insecurity and social vulnerability may provide a pragmatic entry point for identifying at-risk populations, while integrated interventions that combine material support with social engagement may be particularly effective. More broadly, Indonesia may be understood as indicative of wider transitions occurring across LMICs, where ageing, inequality, and social change converge to reshape patterns of vulnerability.

Several limitations should be considered when interpreting these findings. First, although the longitudinal design allows examination of trajectories, causal inference remains limited. Second, food insecurity and social networks were measured at two time points, which may not fully capture short-term fluctuations or more complex trajectories over time. Third, the social network measure focuses on structure and diversity rather than tie quality or strength and therefore may not fully reflect the functional dimensions of support. The analysis was conducted within a single national context; while Indonesia is informative, generalizability to other settings should be made with caution, particularly where welfare systems and cultural norms differ.

5. Conclusion

This study demonstrates that food insecurity and social network vulnerability co-occur, interact, and change over time to shape health and healthcare utilization in mid- and later life. The findings highlight a form of compounded vulnerability in which material deprivation and relational fragility jointly structure risk across multiple domains, including nutrition, mental health, and access to care. By adopting a joint exposure and longitudinal perspective,

the study moves beyond static and single-factor approaches, contributing to a more comprehensive understanding of ageing inequalities.

From a policy perspective, the results suggest that addressing food insecurity in ageing populations requires a shift from purely material interventions towards approaches that also strengthen relational infrastructures. Integrating social network considerations into food security and health strategies may improve both prevention and access, particularly in LMIC contexts where informal support systems remain central yet increasingly fragile. Future research should further examine dynamic and intersecting vulnerabilities across contexts and explore interventions that simultaneously address material and relational dimensions of ageing.

Human ethics and consent to participate

Ethical approval

for the original IFLS data collection was obtained from the relevant institutional review boards. As the present study involved secondary analysis of de-identified data and did not involve direct contact with human participants, no additional ethical approval was required. No study registration was applicable to this secondary data analysis. Written informed consent was obtained from participants in the original IFLS data collection.

Declarations

Consent for publication

Not applicable.

Competing interest

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

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Author Contribution

YAP: Conceptualization, data curation, formal analysis, writing – original draft, writing – review & editing. MV: Writing – review & editing. AKH: Writing – review & editing. JS: Conceptualization, funding acquisition, supervision, data curation, formal analysis, writing – original draft, writing – review & editing. All authors reviewed the manuscript.

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Data Availability

The data that support the findings of this study are available from the RAND Corporation (Indonesian Family Life Survey, IFLS). Restrictions apply to the availability of these data, which were used under license for this study. Data are available from RAND upon registration at the RAND Corporation website: [https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS.html].

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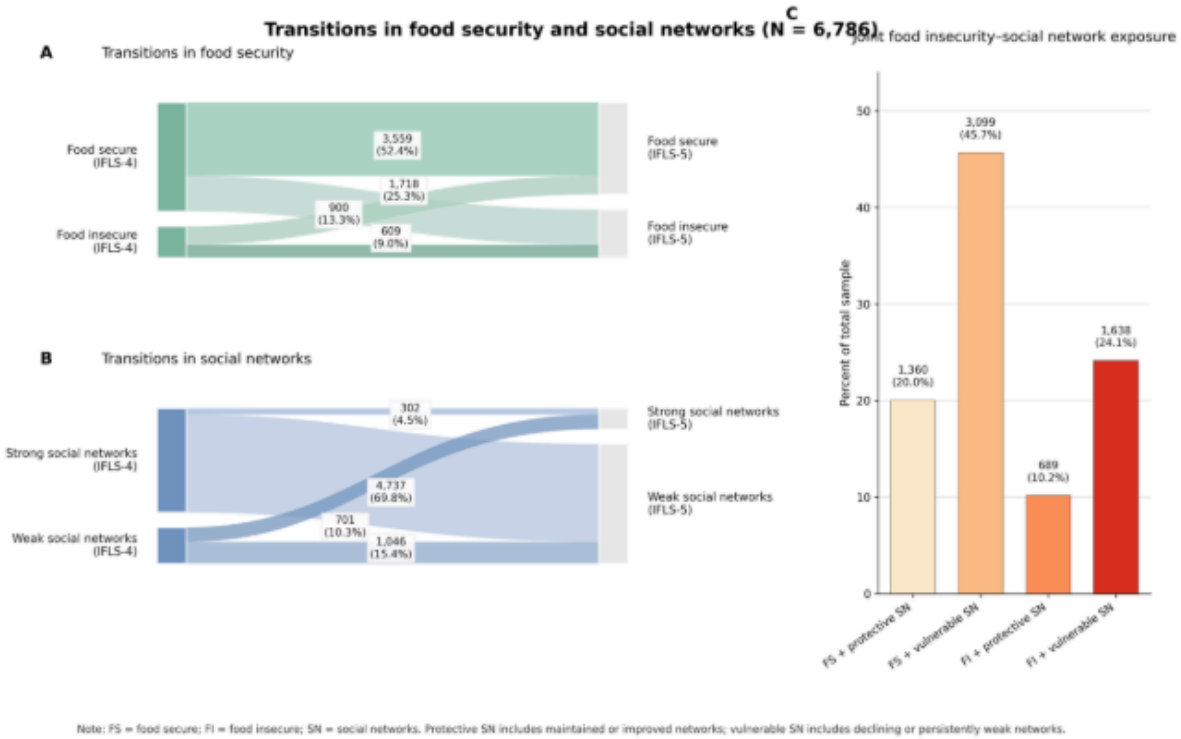
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Figures



Note: FS = food secure; FI = food insecure; SN = social networks. Protective SN includes maintained or improved networks; vulnerable SN includes declining or persistently weak networks.

Figure 1

Transitions in food insecurity and social networks between IFLS-4 (2007/08) and IFLS-5 (2014/15) among adults aged 40 years and older in Indonesia (N = 6,786).