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Food insecurity partially mediates associations between social disadvantage and body composition among older adults in india: Results from the study on global AGEing and adult health (SAGE)

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Abstract

Objective: Our objective was to test whether food insecurity mediates cross-sectional associations between social disadvantage and body composition among older adults (aged 50+) in India ($n = 6556$).

Methods: Adjusting for key sociodemographic and dietary variables, we examined whether markers of social disadvantage (lower educational attainment, lower household wealth, belonging to a disadvantaged caste/tribe, and belonging to a minority religion) were associated with food insecurity. We then examined whether food insecurity, in turn, was associated with anthropometric measures of body composition, body mass index (BMI), and waist circumference (WC). We also tested whether food insecurity mediated the relationship between social disadvantage and body composition.

Results: In adjusted models, lower household wealth [lowest quintile (Q5) vs highest quintile (Q1): odds ratio (OR) = 13.57, $P < .001$], having less than a high-school education (OR = 2.12. $P < .005$), being Muslim (OR = 1.82, $P < .001$), and being in a scheduled caste (historically marginalized) (OR = 1.49, $P < .005$) were associated with greater food insecurity. Those who were severely food insecure had greater odds of being underweight (OR = 1.36, $P < .01$) and lower odds of high WC (OR = 0.70, $P < .01$). Mediation analyses estimated that food insecurity explained 4.7%–29.7% of the relationship between social disadvantage and body composition, depending on the variables considered.

Conclusions: Our results are consistent with the hypothesis that food insecurity is a mechanism linking social disadvantage and body composition among older adults in India. These analyses contribute to a better understanding of processes leading to variation in body composition, which may help enhance the design of interventions aimed at improving population nutritional status.

KEYWORDS
body mass index, caste, food insecurity, religion, waist circumference

1 | INTRODUCTION

Dimensions of social disadvantage, such as low socioeconomic status or marginalized minority identities, are often associated with increased morbidity and mortality (Balarajan, Selvaraj, & Subramanian, 2011; Kuzawa & Sweet, 2009; Murray et al., 2006; Pickett & Wilkinson, 2015, Valeggia & Snodgrass, 2015). Many dimensions of social disadvantage exert their effects across the life course, from prenatal environments to older adulthood (Braveman et al., 2015; Crews, 1998; Poulton et al., 2002; Szanton et al., 2010). However, the specific processes linking social disadvantage and health in older adults are not well described. Experiences of social adversity during critical early life developmental periods may have lasting effects on physiological systems (Hertzman & Boyce, 2010; Himmelgreen, 2013; Kuzawa & Quinn, 2009). Furthermore, social adversity may have cumulative effects across the life course, culminating in poorer health outcomes in older adults (Ice, 2005; Willson, Shuey, & Elder, 2007). In addition, social disadvantage may limit access to material and social resources that are beneficial to health (Groffen et al., 2008; Read, Grundy, & Foverskov, 2016; Thayer & Kuzawa, 2014).

One resource that is beneficial to health is having consistent access to nutritionally sufficient, safe, and socially acceptable foods (Stuff et al., 2004; Weaver & Hadley, 2009). The absence of these conditions has been termed "food insecurity" (Barrett, 2010; Moffat, Mohammed, & Newbold, 2017). There are multiple possible pathways connecting social disadvantage across the life course to food insecurity and health in older adulthood. Those born into settings of social disadvantage may face adverse environments early in life and, as a result, experience poorer health (Braveman et al., 2015). Poorer health may, in turn, be associated with lower earning potential in younger adulthood (Halla & Zweimüller, 2013). Limited earnings in younger adulthood may constrain financial resources, thus leaving individuals vulnerable to food insecurity in older adulthood (Gulliford, Mahabir, & Rocke, 2003; Gundersen, Kreider, & Pepper, 2011). Food insecurity in older adults may influence body composition (Ahn, Smith, Hendricks, & Ory, 2014; Brewer et al., 2010). Body composition, in turn, may impact risks for morbidity and mortality (Beck et al., 1999; Winter et al., 2014). The effects of food insecurity on body composition may be one mechanism linking social disadvantage to increased morbidity and mortality in older adults. In this study, we test whether recent experiences of food insecurity (in the past 12 months) mediate associations between social disadvantage and body composition among older adults in India.

1.1 | Body composition and health in older adults

Body composition is a key factor in shaping health and functional status among older adults. Studies have generally reported a U-shaped association between body mass index (BMI) and mortality among older adults, with the highest mortality rates being reported in the upper and lower extremes of BMI (Winter et al., 2014). The optimal BMI for survival may increase with age. For example, after adjusting for smoking status and known pre-existing illness, a recent study of nearly 13 million Korean adults found that optimal BMI ranges for men in terms of survival were 23.0–25.9 (kg/m^2) for those aged 18–34, 24.0–27.9 for those aged 45–54, and increasing to 25.0–28.9 for those aged 65–74 (Yi et al., 2015). The corresponding ranges for women in the same study were 15.5–24.9 for those aged 18–34, 21.0–26.9 for those aged 45–54, and 24.0–28.9 for those aged 65–74. Several studies have reported that older adults who are underweight are at greater risk for overall mortality compared to those who are in the normal or overweight BMI categories (Chung, Ho, Cheng, Lee, & Yeh, 2015; Diehr et al., 1998; Grabowski & Ellis, 2001; Locher et al., 2007). Underweight and undernutrition have also been linked to greater risks for disability, acute illness, and frailty in older adults (Beck et al., 1999; Visscher et al., 2000; Fugate Woods et al., 2005). On the other end of the BMI distribution, obesity is a risk factor for chronic diseases and may exacerbate age-related declines in physical functioning among older adults (Ezzati et al., 2002; Villareal et al., 2005; Woods et al., 2005).

1.2 | Socioeconomic status and body composition

Associations between socioeconomic status (SES) and anthropometric markers of body composition, such as body mass index (BMI), are well established (Sobal & Stunkard, 1989). This association tends to be positive in lower income countries (i.e., lower SES is associated with lower BMI) and gradually reverse with increasing levels of economic development, becoming negative in higher income countries (i.e., lower SES is associated with greater BMI) (McLaren, 2007). This reversal of the SES-BMI gradient tends to occur first and be most consistent among women (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012). Though there is a persistent association across a wide range of countries between SES and body composition (Dinsa et al., 2012; McLaren, 2007; Sobal & Stunkard, 1989), the mechanisms linking SES and body composition are unclear. Food insecurity may be one such mechanism.

1.3 | Social disadvantage and food insecurity

A number of studies in high-income countries have reported associations between social disadvantage and food insecurity (Gundersen, Kreider, & Pepper, 2011). For example, one study of Finnish adults reported that lower socioeconomic status was associated with a greater probability of food insecurity (Sarlio-Lähteenkorva & Lahelma, 2001). Another study reported that income was negatively associated with reported experiences of hunger in the United States (Rose, 1999). A third study found that increases in income were associated with decreases in the severity of food insecurity among families in high-poverty neighborhoods in Toronto (Loopstra & Tarasuk, 2013). Studies in low- to middle-income countries have also reported associations between social disadvantage and food insecurity. For example, a study in China found that children in the poorest quintile were five times more likely to reside in a food insecure household than those in the wealthiest quintile (Hannum, Liu, & Frongillo, 2014). A study among adolescents in Ethiopia found that the odds of being food insecure were three and a half times greater among those in low-SES households as compared to those in high-SES households (Hadley, Lindstrom, Tessema, & Belachew, 2008). A third study among adults in Trinidad and Tobago found that lower levels of educational attainment and lower household incomes were associated with greater odds of being food insecure (Gulliford et al., 2003). Given that the Food and Agriculture Organization of the United Nations (FAO) estimates that 805 million people suffer from undernutrition (The State of Food Insecurity in the World, 2014), further work on the links between social disadvantage and food insecurity is warranted to improve the design of policy, public health, and medical interventions. The need for further research is particularly acute among older adults in low- to middle-income countries, a group that is often underrepresented in this literature.

1.4 | Food insecurity and body composition

Most of the studies examining associations between food insecurity and body composition have been conducted in high-income countries. Though results of these studies have been mixed, a number have reported that food insecurity is linked to a greater risk of obesity or overweight, the association being most consistent in women (Dinour, Bergen, & Yeh, 2007; Martin & Ferris, 2007; Wilde & Peterman, 2006). There is also some evidence to suggest that similar trends exist among older adults (Ahn et al., 2014; Brewer et al., 2010). The studies that have examined food insecurity and body composition in low- to middle-income countries have produced inconsistent results. For example, a study of adults and school children in Bogotá, Colombia, reported that food insecurity was associated with underweight but not overweight (Isanaka, Mora-Plazas, Lopez-Arana, Baylin, & Villamor, 2007). Another study conducted among adults in urban Kampala, Uganda found no significant associations with body mass index (BMI) or waist circumference (WC), after adjusting for covariates (Chaput, Gilbert, & Tremblay, 2007). A third study reported that food insecurity was associated with at-risk (i.e., high) waist circumference (WC) in a sample of rural women in Malaysia (Shariff & Khor, 2005). These results suggest that further work is needed to understand how the links between food security and body composition vary across populations and to identify the specific factors in each setting that influence this relationship.

1.5 | Study context

India is a particularly compelling case with regard to the intersection of social inequality, food insecurity, and body composition among older adults due to a rapidly aging population, high rates of underweight and undernutrition, and an increasing prevalence of obesity-related chronic disease as a result of the country's transitioning nutritional environment (Paul et al., 2011; Popkin et al., 2012). Furthermore, India is home to a substantial proportion of the world's population, with current estimates over 1.2 billion, and India's older adult (aged 60+) population is projected to exceed 330 million by 2050 (World Population Prospects: The 2015 Revision, 2015). A distinct form of inequality in India is the caste system. Scheduled tribes and scheduled castes are historically marginalized and socially excluded groups that the government has identified as targets for affirmative action (Kijima, 2006). Multiple lines of evidence demonstrate that members of scheduled tribes and scheduled castes face systematic discrimination in access to the labor market, education, and public infrastructure (Madheswaran & Attewell, 2007; Thorat & Attewell, 2007; Thorat & Lee, 2005; Thorat & Newman, 2007). Recently, an interest in the effects of the caste system on health disparities has emerged (Kowal & Afshar, 2015; Radhamanohar, 2015). However, views differ regarding the precise role of the caste system in shaping patterns of health. While some argue that the caste system only indirectly influences health by modifying socioeconomic factors such as education and income (Radhamanohar, 2015), others maintain that the caste system impacts health independently of other socioeconomic factors (Kowal & Afshar, 2015). One study found that those in lower caste groups experienced a disproportionate burden of mortality, even after adjusting for gender and standard of living (Subramanian et al., 2011). Remarkably, however, few other studies have empirically evaluated associations between caste membership and markers of health status, controlling for conventional measures of SES.

In the past three decades, India has exhibited declines in average calorie intake and slow improvement in anthropometric indicators of nutritional status despite rapid economic development and increases in real income (Subramanyam, Kawachi, Berkman, & Subramanian, 2011). Given that rates of undernutrition are higher than would be expected for its level of economic development and growth (Deaton & Dreze, 2009), identifying factors that contribute to food insecurity and undernutrition in India is critical. This is particularly true among older adults, a group that experiences increased vulnerability to environmental adversity (Topinkova, 2008).

2 | OBJECTIVES

Objective 1**:** To examine associations between socioeconomic factors and food insecurity. We hypothesize that disadvantaged SES (e.g., lower household wealth, scheduled caste membership) will be associated with greater risks of being food insecure.

Objective 2**:** To test whether food insecurity is associated with anthropometric measures of body composition. We hypothesize that food insecurity will be associated with a greater odds of underweight BMI and lower odds of elevated BMI and WC.

Objective 3**:** To test whether food insecurity mediates the association between social disadvantage and body composition. We hypothesize that food insecurity will partially mediate this association.

3 | METHODS

We tested these hypotheses using cross-sectional data from a nationally representative sample of older Indian adults (aged 50+) drawn from the World Health Organization's (WHO) Study of global AGEing and adult health (SAGE) India Wave 1 ($n = 6556$), which was collected in 2007. SAGE is a study implemented in six low- to middle-income countries that focuses on older adults. It includes data in multiple domains related to health and aging including healthcare expenditures, anthropometrics, chronic disease, psychosocial wellbeing, and disability. SAGE is described in greater detail elsewhere (Kowal et al., 2012).

3.1 | Study sample

The SAGE India Wave 1 sample is composed of individuals from six states in India: Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal. For sampling purposes, Indian states were grouped into six geopolitical regions and six levels of economic development. Six states were then randomly selected such that there was one state from each region and one state from each level of economic development. For the purposes of sampling households for participation in the study, city wards were the primary sampling units (PSUs) in urban areas and villages were the PSUs in rural areas. Primary sampling units were sampled based on probability proportional to size. Households were randomly sampled within PSUs and, in households with older adult study participants, all older adults in the household were recruited. Of older adults in the study (aged 50+), 73% had ever worked, and 43% were currently working (Arokiasamy, Parasuraman, Sekher, & Lhungdim, 2013). Most households in the study reported receiving income from multiple sources, and 55% of households reported that their income was insufficient to meet household needs (Arokiasamy et al., 2013). Information was also collected on selected chronic diseases. Of the older adult sample, 26% reported having one of these conditions, and 16% reported having more than one (Arokiasamy et al., 2013). The chronic condition reported by the highest proportion of the older adult sample was arthritis (18%) followed by hypertension (17%) (Arokiasamy et al., 2013). Of older adults, 52% reported at least one deficiency in activities of daily living (ADL) (Arokiasamy et al., 2013). In this study, 74.4% of respondents were rural residents and 51.3% had no formal education (Table 1).

3.2 | Body composition

Height, weight, and waist circumference were measured at the time of the interview using standard anthropometric techniques. The outcome variables used in this study were food insecurity, BMI (kg/m^2), and WC (cm). Because BMI is limited as an indicator of obesity, especially in older adults (Bhurosy & Jeewon, 2013), it has been recommended that it be used alongside other measures that may better reflect abdominal adiposity, such as WC. Therefore, we included both measures in this study.

Evidence in recent years supports the use of adjusted cutoff values for BMI and WC when studying Asian populations. Epidemiological studies indicate that Asian populations, including those from India, experience elevated risks for cardiovascular and metabolic diseases at lower BMI and WC values compared to those in other populations (Misra et al., 2006; World Health Organization, 2004). A study among 10,025 Asian Indian adults found that the optimal BMI cutoff value for predicting diabetes, balancing specificity and sensitivity, was 23 kg/m^2, rather than the international standard of 25 kg/m^2 (Snehalatha, Viswanathan, & Ramachandran, 2003). Furthermore, Asian Indians exhibit higher rates of overweight, as assessed using skinfolds, at lower levels of BMI compared to other populations (Dudeja et al., 2001). A study of 2,050 adult Asian Indians found that adjusted WC cutoffs (men >90 cm, women >80 cm) showed greater sensitivity and improved classification of cardiovascular risk factors compared to the one-size-fits-all

TABLE 1 Sample characteristics and bivariate statistical significance by level of food insecurity among older adults in India ($n = 6556$)[a]

	Secure (n = 5406)	Moderately insecure (n = 669)	Severely insecure (n = 481)	Total (n = 6556)
Age (mean, SD)	61.84 (9.1)	61.26 (8.5)	62.26 (8.8)	61.86 (9.0)
Sex (n, %)				
Female	2675 (49.5)	337 (50.4)	242 (50.3)	3254 (48.6)
Male	2731 (50.5)	332 (49.6)	239 (49.7)	3302 (50.4)
Marital status (n, %)[b]				
Married	4062 (75.3)	477 (72.5)	321 (65.7)	4860 (74.1)
Unmarried	1344 (24.7)	192 (27.5)	160 (33.3)	1696 (25.9)
Residence (n, %)[b]				
Urban	1510 (27.9)	88 (13.2)	78 (16.2)	1676 (25.6)
Rural	3896 (72.1)	581 (86.8)	403 (83.8)	4880 (74.4)
Number of children (n = 6519)[b]	1.77 (2.1)	1.65 (1.9)	1.58 (1.9)	1.75 (2.0)
Wealth (n, %) (n = 6518)[b]				
1st Quintile (wealthiest)	1553 (28.9)	40 (6.0)	32 (6.7)	1625 (24.9)
2nd Quintile	1272 (23.7)	80 (12.1)	55 (11.5)	1407 (21.6)
3rd Quintile	1027 (19.1)	115 (17.4)	64 (13.4)	1206 (18.5)
4th Quintile	907 (16.9)	183 (27.6)	128 (26.8)	1218 (18.7)
5th Quintile (poorest)	619 (11.5)	244 (36.9)	199 (41.6)	1062 (16.3)
Education level (n, %)[b]				
High school or higher	814 (15.1)	26 (3.9)	25 (5.2)	865 (13.2)
Less than high school	1965 (36.3)	227 (33.9)	136 (28.3)	2328 (35.5)
No formal education	2627 (48.6)	416 (62.2)	320 (66.5)	3363 (51.3)
Caste membership (n, %) (n = 6534)[b]				
Other	4283 (79.4)	445 (67.3)	321 (66.9)	5049 (77.3)
Scheduled caste	800 (14.8)	154 (23.3)	131 (27.3)	1085 (16.6)
Scheduled tribe	310 (5.7)	62 (9.4)	28 (5.8)	400 (6.1)
Religion (n, %)[b]				
Hindu	4617 (85.4)	523 (78.2)	389 (80.9)	5529 (84.3)
Other	199 (3.7)	19 (2.8)	19 (4.0)	237 (3.6)
Muslim	590 (10.9)	127 (19.0)	73 (15.2)	790 (12.1)
Body mass index (n, %) (n = 6367)[b]				
Underweight	1692 (32.2)	313 (48.0)	232 (50.7)	2237 (35.1)
Normal	2168 (41.2)	248 (38.0)	171 (37.3)	2587 (40.6)
Elevated	1397 (26.6)	91 (14.0)	55 (12.0)	1543 (24.2)
Waist circumference (n, %) (n = 6424)[b]				
Normal	3168 (59.7)	504 (76.8)	353 (75.9)	4025 (62.7)
Elevated	2135 (40.3)	152 (23.2)	112 (24.1)	2399 (37.3)
Fruit intake (mean, SD) (n = 6448)	0.94 (1.0)	0.56 (0.9)	0.83 (0.9)	0.90 (1.0)
Vegetable intake (mean, SD) (n = 6551)[b]	2.01 (0.9)	1.81 (1.2)	1.92 (1.2)	1.98 (1.0)

SD, standard deviation.

[a]Associations with categorical variables were tested using Pearson's Chi-squared tests. Associations with continuous variables were tested using one-way ANOVA.

[b]Statistically significant at $P < .001$.

international standard (men >102 cm, women >88 cm) (Misra et al., 2006). Adjusted cutoffs have also been increasingly utilized in clinical medicine (e.g., Hsu, Araneta, Kanaya, Chiang, & Fujimoto, 2015), and public health researchers and physicians in India have adopted revised cutoff values for Asian Indian populations by consensus (Misra et al., 2009). Based on these lines of evidence, we categorized the outcome variables using the modified cutoff values recommended for Asian (including Asian Indian) populations (Misra et al., 2006; World Health Organization, 2004). The categories used for BMI were "underweight" (<18.5 kg/m^2), "normal" (18.5–22.9 kg/m^2), and "elevated" (≥ 23 kg/m^2). The categories for WC were "normal" (men ≤ 90 cm, women ≤ 80 cm) and "elevated" (men >90cm, women >80 cm). In statistical models, "normal WC" and "normal BMI" were used as referent categories.

3.3 | Socioeconomic and demographic variables

Educational attainment was assessed using responses to survey items. Participants were asked whether or not they had any formal education. If they answered "yes," they were prompted to select their highest level of education completed, ranging from "less than primary" to "postgraduate degree." Responses were grouped into three categories for analysis: "no formal education," "less than high school," and "high school or greater." For the purposes of data analysis, "high school or greater" was treated as the referent category.

To create the household wealth variable, households were scored based on the possession of durable goods (e.g., cars, mobile phones, washing machines), dwelling characteristics (e.g., types of floors, walls, and cooking stoves), and access to services (e.g., improved water, sanitation, and cooking fuel). Responses for each of 21 items were recoded with "1" denoting the possession of that item or access to it or "0" to indicate its absence. The dataset was then reshaped, treating each response item as a separate observation for wealth. A pure random effect model was then fitted. This produced indicator-specific thresholds for a latent wealth scale, such that a household is more likely to respond affirmatively than not when its wealth exceeds this threshold. Using an empirical Bayes postestimation method, households were arranged into a country-specific asset ladder. These raw scores were then transformed into quintiles. The highest wealth quintile was used as the referent category in statistical analyses.

Respondents were asked a question regarding their caste membership. Possible responses included "scheduled tribe" and "scheduled caste." Each of these two responses was placed into their own category. All other responses including "other caste," "no caste," and "do not know" were categorized as "other," which was used as the referent category.

We created a variable based on a survey item asking respondents about their religious affiliation. "Muslim" and "Hindu" were placed in their own categories. All other responses such as "Christian," "Buddhist," and "none" were categorized as "other." For statistical analysis, we used "Hindu" as the referent category.

3.4 | Fruit and vegetable intake

It is possible that dietary restrictions based on religion or caste may influence the relationship between social variables and body composition. For example, those of certain castes may be more likely to adhere to a vegetarian diet. To help account for this possibility we included variables on fruit and vegetable intake. Respondents were asked, "How many servings of *fruit* do you eat on a typical day?" with country-specific examples of fruits given by the interviewer. In addition, an analogous question regarding vegetable consumption was asked. Both fruit and vegetable intake were included as continuous variables in statistical models.

3.5 | Number of children in household

Adults may buffer the nutritional status of children in their household by restricting their own food intake (McIntyre et al., 2003). To control for this possibility, we constructed a variable reflecting the number of children in a participant's household aged 13 or younger.

3.6 | Food insecurity

Food insecurity was assessed using two questions with five-point Likert scale-type response categories. One of these items asked, "In the *last 12 months*, how often did you ever eat less than you felt you should because there wasn't enough food?" This item was adapted from similar items in established food security questionnaires (e.g., item AD2 of the U.S. Household Food Security Survey Module: Six-Item Short Form (https://www.ers.usda.gov/media/8282/short2012.pdf); item FSQ.061 of the National Health and Nutrition Examination Study (NHANES) Food Security module (https://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/FSQ_Family_H.pdf)). The other item asked, "In the *last 12 months*, were you ever hungry, but didn't eat because you couldn't afford enough food?" This item corresponds to item AD3 of the U.S. Household Food Security Survey Module: Six-Item Short Form and item FSQ.071 of the NHANES Food Security module. Response categories for both items ranged from 1 to 5 (1 = every month; 2 = almost every month; 3 = some months, but not every month; 4 = only in one or two months; 5 = never). These responses were used to construct a three-level food insecurity variable. Owing to the broad scope of the SAGE questionnaire, these questions were intended to be variables indicative of food insecurity but they do not constitute a comprehensive food security measure. Similar approaches have been used in other large-scale health studies such as the Australian Health Survey, which has at times used only one item (Nolan, Williams, Rikard-Bell, & Mohsin, 2006). When compared to an abridged version of the U.S. Household Food Security Survey Module, the one-item approach in the Australian Health Survey had high specificity (96%) but lower sensitivity (56.9%; Nolan et al., 2006). Though the two items included in the SAGE questionnaire were insufficient to create a continuous food insecurity score, we wanted to create a variable with greater nuance than provided by a binary food secure/insecure variable. Therefore, we created a three-level food insecurity variable. The two considerations that determined the categorization of our food insecurity variable were face validity and maintaining sufficient cell sizes of each food insecurity category for multinomial logistic regression analysis. Those who answered 1 through 3 to both items *or* answered 1 to either item were categorized as severely food insecure. Those who did not meet the criteria for severe food insecurity but answered 2 through 4 for either item were coded as moderately food insecure. Those who answered 5 to both items were categorized as food secure. In statistical analyses, being food secure was used as the referent category.

3.7 | Data analysis

Chi-square tests and one-way ANOVA were used to test for significant bivariate associations between food insecurity and the variables described above. Multivariate analyses were performed separately for each of the three outcome variables: food insecurity, BMI, and WC. Multinomial logistic regression was used to predict categories of food insecurity and BMI, and binary logistic regression was used to predict the presence of elevated WC. In models predicting food insecurity, the variables entered into the model were age, sex, marital status, urban versus rural residence, number of children in household, wealth quintile, education level, caste membership, religion, fruit intake, and vegetable intake. In models predicting BMI and WC, the aforementioned variables, plus food insecurity, were used. For each multivariate analysis, a model was first specified without the education and wealth variables, followed by the full model including these variables. Owing to the multiple comparisons tested, associations were considered statistically significant at $P < .01$, rather than the conventional $P < .05$. All analyses were conducted in R 3.2.

Mediation analyses were conducted using the "mediation" package version 4.4.5 in R. This package uses regression coefficients to estimate indirect effects (IE) (Tingley, Yamamoto, Hirose, Keele, & Imai, 2012). To estimate the IE, two regression models are fitted. The "mediator" model consists of the exposure variable and covariates predicting the mediator variable. The "outcome" model consists of the exposure variable, mediator variable, and covariates predicting the outcome variable. The package then uses a quasi-Bayesian Monte Carlo method based on a normal approximation to estimate the IE (Imai, Keele, & Tingley, 2010). One thousand simulations were used for each mediation analysis. For the purposes of mediation analysis, food insecurity, all four social disadvantage variables, and both body composition variables were dichotomized. Food insecurity was dichotomized by grouping together the moderate and severe food insecurity categories and leaving the secure category intact. Education was categorized as less than high school versus high school or greater. Household wealth was categorized as the lowest quintile versus all other quintiles. Caste membership was dichotomized as scheduled tribe or caste versus all other affiliations. Religion was dichotomized as Muslim versus all other affiliations. All models used in mediation models used the same covariates as the multivariate regression models described in the previous paragraph. For each mediation analysis, we report the IE, the 99% confidence interval (99% CI), *P* value, and proportion mediated (PM, i.e., the proportion of the total effect explained by the IE).

3.8 | Missing values

Of the initial sample of 6,560, 4 individuals were missing values for food insecurity. These observations were removed, leaving an analytical sample of 6,556. Of the analytical sample, 350 individuals were missing values for number of children, wealth quintile, caste, BMI, WC, fruit intake, or vegetable intake. In each statistical test, observations with missing values for the relevant variables were deleted listwise. We tested for differences in age, sex, and urban versus rural residence between individuals with and without missing values. Differences in sex [$\chi^2(1) = 1.68$, $P = .196$] and urban versus rural residence [$\chi^2(1) = 0.14$, $P = .708$] were not statistically significant. However, those with missing values were significantly older (64.02 vs 61.69) than those without missing values [$t(372.6) = -3.71$, $P < .001$]. This may be due to a reduction with age in endurance for performing activities such as responding to surveys. Nevertheless, the mean difference in age is not of a magnitude that is likely to substantially affect results. Furthermore, we held age constant in all multivariate analyses.

4 | RESULTS

An absence of food insecurity was reported by 82.5% of respondents, moderate food insecurity was reported by

10.2%, and severe food insecurity was reported by 7.3%. Of participants, 40.6% had normal BMI, 35.1% were underweight, and 24.2% had elevated BMI. In addition, 62.7% had low WC and 37.3% had elevated WC. Additional sample characteristics and bivariate statistical significance levels are shown in Table 1.

4.1 | Objective 1: Socioeconomic factors and food insecurity

In the fully adjusted multinomial logistic regression model predicting "secure," "moderately insecure," and "severely insecure" categories of food insecurity, those in poorer households had significantly greater odds of moderate [poorest quintile (Q5) vs wealthiest quintile (Q1): odds ratio (OR) = 9.31; 99% confidence interval (99% CI) = 5.64, 15.36; $P < .001$] and severe (Q5 vs Q1: OR = 13.57; 99% CI = 7.66, 24.04; $P < .001$) food insecurity (food secure was the referent category for all analyses). Having less than a high school education vs having completed high school or higher was associated with greater odds of moderate food insecurity (OR = 2.12; 99% CI = 1.15, 3.90; $P < .005$). Being in a scheduled caste was associated with greater odds of severe food insecurity (OR = 1.49; 99% CI = 1.08, 2.06; $P < .005$). Muslims had greater odds of moderate food insecurity as compared to Hindus (OR = 1.82; 99% CI = 1.32, 2.51; $P < .001$). Complete odds ratios, 99% confidence intervals, and statistical significance levels from multinomial logistic regression models are presented in Table 2.

4.2 | Objective 2: Food insecurity and body composition

In a multinomial logistic regression model including all covariates except wealth and education, moderate (OR = 1.40; 99% CI = 1.10, 1.79; $P < .001$) and severe (OR = 1.66; 99% CI = 1.25, 2.21; $P < .001$) food insecurity were associated with greater odds of underweight versus normal BMI. Moderate (OR = 0.66; 99% CI = 0.47, 0.93; $P < .005$) and severe (OR = 0.55; 99% CI = 0.36, 0.84; $P < .001$) food insecurity were also associated with lower odds of elevated BMI. After adjusting for wealth and education, the association between severe food insecurity and greater odds of underweight BMI remained significant (OR = 1.36; 99% CI = 1.01, 1.82; $P < .01$). Complete odds ratios, 99% confidence intervals, and statistical significance levels from multinomial logistic regression models are featured in Table 3.

In a binomial logistic regression model including all covariates except wealth and education, moderate (OR = 0.51; 99% CI = 0.39, 0.67; $P < .001$) and severe (OR = 0.50; 99% CI = 0.36, 0.68; $P < .001$) food insecurity were associated with lower odds of elevated WC. After adjusting for wealth and education, these associations remained significant for both moderate (OR = 0.67; 99% CI = 0.50, 0.89; $P < .001$) and severe (OR = 0.70; 99% CI = 0.50, 0.97; $P < .01$) food insecurity. Complete odds ratios, 99% confidence intervals, and statistical significance levels from binary logistic regression models are presented in Table 4.

4.3 | Objective 3: Food insecurity as a mediator

Food insecurity positively mediated the associations of having less than a high-school education (IE = 0.0084; 99% CI = 0.0033, 0.0143; $P < .01$; PM = 0.0635), being in the lowest wealth quintile (IE = 0.0196; 99% CI = 0.0103, 0.0301; $P < .01$; PM = 0.1445), being in a scheduled tribe or caste (IE = 0.0049; 99% CI = 0.0015, 0.010; $P < .01$; PM = 0.0642), and being Muslim (IE = 0.0081, 99% CI = 0.0034, 0.0144; $P < .01$; PM = 0.2970) with underweight BMI. Food insecurity also negatively mediated the associations of having less than a high-school education (IE = −0.0086; 99% CI = −0.0139, −0.0044; $P < .01$; PM = 0.0781), being in the lowest wealth quintile (IE =-0.0167; 99% CI = −0.0253, −0.0096; $P < .01$; PM = 0.1192), being in a scheduled tribe or caste (IE =-0.0042; 99% CI = −0.0079, −0.0011; $P < .01$; PM = 0.0468), and being Muslim (IE = −0.0078; 99% CI = −0.0142, −0.0033; $P < .01$; PM = 0.2621) with elevated WC.

4.4 | Interactions terms and multicollinearity

We tested interaction terms between food insecurity and socioeconomic variables in predicting categories of BMI and WC. However, none of these terms were statistically significant. Our inclusion of multiple socioeconomic factors in logistic regression models creates the potential for issues related to multicollinearity. However, the variance inflation factors (VIF) for all predictor variables used in regression models were <3 (the conventional rule of thumb is VIF < 10), which suggests that issues of multicollinearity were unlikely to have had substantial effects on our statistical models (O'Brien, 2007).

5 | DISCUSSION

The results of this study are consistent with our first hypothesis that socioeconomic disadvantage would be associated with greater risks of food insecurity. Having lower household wealth, having less than a high-school education, being Muslim, and being in a scheduled caste were all associated

TABLE 2 Odds ratios and 99% confidence intervals from multinomial logistic regression models predicting levels of food insecurity among older adults in India ($n = 6390$)

	Model 1	Model 2
Moderately insecure vs. secure		
Age	0.99 (0.98, 1.01)	0.99 (0.98, 1.00)
Female	0.97 (0.77, 1.23)	0.99 (0.77, 1.29)
Married	0.83 (0.63, 1.09)	0.92 (0.70, 1.21)
Rural residence	2.16 (1.58, 2.97)[c]	1.31 (0.94, 1.83)
Number of children	0.91 (0.86, 0.97)[c]	0.96 (0.91, 1.02)
Wealth (ref = wealthiest quintile)		
Second quintile		1.95 (1.16, 3.27)[c]
Third quintile		3.07 (1.85, 5.09)[c]
Fourth quintile		5.18 (3.16, 8.48)[c]
Fifth quintile (Poorest)		9.31 (5.64, 15.36)[c]
Education level (ref = high school or higher)		
Less than high school		2.12 (1.15, 3.90)[b]
No formal education		1.86 (0.99, 3.49)
Caste membership (ref = other)		
Scheduled tribe	1.81 (1.21, 2.71)[c]	1.27 (0.83, 1.93)
Scheduled caste	1.81 (1.37, 2.40)[c]	1.28 (0.96, 1.72)
Religion (ref = Hindu)		
Muslim	2.42 (1.78, 3.29)[c]	1.82 (1.32, 2.51)[c]
Other	0.68 (0.33, 1.43)	0.72 (0.34, 1.55)
Fruit intake	0.69 (0.59, 0.80)[c]	0.82 (0.70, 0.95)[c]
Vegetable intake	0.92 (0.80, 1.05)	0.99 (0.87, 1.12)
Severely insecure vs. secure		
Age	1.00 (0.99, 1.02)	1.00 (0.98, 1.01)
Female	0.98 (0.75, 1.29)	0.94 (0.70, 1.28)
Married	0.67 (0.50, 0.91)[c]	0.78 (0.57, 1.07)
Rural residence	1.97 (1.40, 2.76)[c]	1.01 (0.70, 1.45)
Number of children	0.91 (0.84, 0.97)[c]	0.97 (0.90, 1.04)
Wealth (ref = wealthiest quintile)		
Second quintile		2.01 (1.10, 3.65)[b]
Third quintile		2.80 (1.54, 5.10)[c]
Fouth quintile		6.57 (3.72, 11.61)[c]
Fifth quintile (lowest)		13.57 (7.66, 24.04)[c]
Education level (ref = high school or higher)		
Less than high school		1.35 (0.73, 2.50)
No formal education		1.58 (0.84, 2.98)
Caste membership (ref = other)		
Scheduled tribe	1.19 (0.69, 2.07)	0.70 (0.39, 1.25)
Scheduled caste	2.34 (1.72, 3.19)[c]	1.49 (1.08, 2.06)[b]

(Continues)

TABLE 2 (Continued)

	Model 1	Model 2
Religion (ref = Hindu)		
Muslim	1.94 (1.32, 2.83)[c]	1.36 (0.92, 2.02)
Other	0.95 (0.49, 1.86)	1.05 (0.52, 2.12)
Fruit intake	1.08 (0.94, 1.23)	1.21 (1.06, 1.39)[c]
Vegetable intake	0.95 (0.83, 1.09)	1.02 (0.89, 1.16)

Ref, referent category.
[a]Statistically significant at $P < .01$.
[b]Statistically significant at $P < .005$.
[c]Statistically significant at $P < .001$.

with greater odds of food insecurity. Our results also supported our second hypothesis that food insecurity would be associated with greater odds of underweight BMI and lower odds of elevated BMI and WC, though the associations with elevated BMI were attenuated after adjusting for wealth and education. Finally, the results of mediation analyses supported our third hypothesis that food insecurity would partially mediate the associations between social disadvantage and body composition.

Our findings that wealth and educational attainment are negatively associated with food insecurity are congruous with an extensive literature demonstrating that lower SES predicts poorer health and well-being (Adler & Ostrove, 1999; Braveman, Egerter, & Williams, 2011; Pinquart & Sörensen, 2000). Owing to its adverse health consequences, food insecurity associated with lower SES may be one pathway through which social inequality shapes health in this population. Notably, those in scheduled castes were more likely to be food insecure than others, even when accounting for wealth, education, and other demographic and nutritional factors. In addition to predicting various health outcomes, food security itself is an important dimension of quality of life, and an important human rights issue (Campbell, 1991; Sarelin, 2007). A previous study showing that members of low-status castes experience widespread discrimination in access to government food programs illustrates processes through which food insecurity might arise in this group (Thorat & Lee, 2005). Our findings suggest that membership in a marginalized caste may impact health among older adults through its effects on food insecurity.

We found that those who self-identified as Muslim (14.2% of the general population (Census of India, 2011)) had greater odds of being moderately food insecure compared to those of the Hindu majority (79.8% of the general population (Census of India, 2011)). This finding is consistent with reports indicating that Muslims in India face multiple forms of systemic exclusion such as labor market discrimination and residential segregation (Basant, 2007). Our results suggest that older adult Muslims in India may also face disadvantages in access to affordable and nutritious food. However, caution should be exercised in generalizing this finding to India as a whole, as the six states in the SAGE sample (Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal) were selected to be representative in terms of region and economic development but may differ from other states in terms of religious composition.

Our results indicate that food insecurity is associated with anthropometric markers of body composition among older adults in India. Food insecurity was associated with lower odds of elevated WC and BMI, though the association with elevated BMI was no longer statistically significant after adjusting for wealth and education. This difference may be due to WC being a more sensitive indicator of adiposity. Our finding that severe food insecurity is associated with underweight BMI, even after adjusting for multiple covariates including wealth and education, is of particular relevance to the literature on socioeconomic disparities in health. Underweight BMI is a consistent predictor of morbidity and mortality in older adults (Beck, Ovesen, & Osler, 1999; Chung et al., 2015; Diehr et al., 1998; Grabowski & Ellis, 2001). Those who are food insecure may experience a disproportionately high burden of morbidity and mortality due to their greater risks of being underweight. This finding strengthens the case for food insecurity as a potential risk factor for poor health among older adults in low- to middle-income countries.

Mediation analyses suggested that food insecurity partially mediates the associations between multiple dimensions of social disadvantage and body composition. Food insecurity positively mediated the association between social disadvantage variables and underweight BMI, which suggests that social disadvantages may increase the probability of being food insecure, which, in turn, increases risks of being underweight. Food insecurity negatively mediated associations between social disadvantage and elevated WC, which suggests that social disadvantage variables increase risks for food insecurity, which, in turn, decreases risks for elevated WC. These results are consistent with the hypothesis that

TABLE 3 Odds ratios and 99% confidence intervals from multinomial logistic regression models predicting categories of body mass index among older adults in India (n = 6209)

	Model 1	Model 2
Underweight vs. normal		
Age	1.03 (1.02, 1.03)[c]	1.02 (1.01, 1.03)[c]
Female	1.04 (0.88, 1.23)	0.94 (0.78, 1.13)
Married	0.90 (0.74, 1.09)	0.94 (0.77, 1.14)
Rural residence	1.70 (1.39, 2.09)[c]	1.37 (1.11, 1.70)[c]
Number of children	1.01 (0.97, 1.04)	1.02 (0.98, 1.06)
Food insecurity (ref = secure)		
Moderately insecure	1.40 (1.10, 1.79)[c]	1.18 (0.92, 1.52)
Severely insecure	1.66 (1.25, 2.21)[c]	1.36 (1.01, 1.82)[a]
Wealth (ref = wealthiest quintile)		
Second quintile		1.24 (0.96, 1.61)
Third quintile		1.62 (1.24, 2.12)[c]
Fourth quintile		1.76 (1.34, 2.32)[c]
Fifth quintile (poorest)		2.25 (1.67, 3.02)[c]
Education level (ref = high school or higher)		
Less than high school		1.37 (1.01, 1.82)[a]
No formal education		1.61 (1.17, 2.22)[c]
Caste membership (ref = other)		
Scheduled tribe	1.66 (1.22, 2.27)[c]	1.41 (1.03, 1.94)[a]
Scheduled caste	1.35 (1.09, 1.65)[c]	1.16 (0.94, 1.43)
Religion (ref = hindu)		
Muslim	1.18 (0.91, 1.52)	1.03 (0.79, 1.33)
Other	0.78 (0.48, 1.27)	0.82 (0.50, 1.35)
Fruit intake	0.87 (0.79, 0.96)[c]	0.94 (0.85, 1.03)
Vegetable intake	0.93 (0.85, 1.02)	0.95 (0.87, 1.04)
Elevated vs. normal		
Age	0.99 (0.98, 1.00)[a]	0.99 (0.98, 1.00)
Female	1.70 (1.41, 2.05)[c]	1.98 (1.61, 2.44)[c]
Married	1.17 (0.94, 1.47)	1.09 (0.87, 1.37)
Rural residence	0.51 (0.42, 0.61)[c]	0.64 (0.52, 0.78)[c]
Number of children	0.99 (0.95, 1.04)	0.99 (0.94, 1.04)
Food insecurity (ref = secure)		
Moderately insecure	0.66 (0.47, 0.93)[b]	0.84 (0.59, 1.20)
Severely insecure	0.55 (0.36, 0.84)[c]	0.74 (0.48, 1.15)
Wealth (ref = wealthiest quintile)		
Second quintile		0.74 (0.59, 0.94)[c]
Third quintile		0.69 (0.52, 0.90)[c]
Fourth quintile		0.46 (0.34, 0.64)[c]
Fifth quintile (poorest)		0.40 (0.27, 0.58)[c]

(Continues)

TABLE 3 (Continued)

	Model 1	Model 2
Education level (ref = high school or sigher)		
Less than high school		0.93 (0.72, 1.21)
No formal education		0.65 (0.48, 0.88)[c]
Caste membership (ref = other)		
Scheduled tribe	0.68 (0.43, 1.05)	0.85 (0.54, 1.33)
Scheduled caste	0.61 (0.46, 0.81)[c]	0.76 (0.57, 1.01)
Religion (ref = Hindu)		
Muslim	1.27 (0.97, 1.68)	1.50 (1.13, 1.99)[c]
Other	1.94 (1.25, 2.99)[c]	1.82 (1.17, 2.82)[c]
Fruit intake	1.20 (1.09, 1.32)[c]	1.14 (1.04, 1.26)
Vegetable intake	1.05 (0.96, 1.16)	1.03 (0.94, 1.14)[c]

Ref, referent category.
[a]Statistically significant at $P < .01$.
[b]Statistically significant at $P < .005$.
[c]Statistically significant at $P < .001$.

food insecurity is a mechanism linking social disadvantage and body composition.

The strengths of our study lie in its multiple indicators of social disadvantage, inclusion of demographic and dietary covariates, and large, nationally representative sample. Nevertheless, there are several limitations. First, the cross-sectional nature of the data prevents inferences about the temporal direction of the reported relationships. Reverse causation is possible (i.e., body composition affects food insecurity, which, in turn, influences social disadvantage), although this is unlikely for education, religion, and caste, as these factors tend to be determined early in life and are unlikely to change in older adulthood. Second, we used BMI and WC as indirect anthropometric measures of body composition. Changes in body composition occur with aging, including a substantial reduction in fat free mass and muscle mass and an increase in visceral fat, even in the absence of an altered body weight (Wannamethee, Shaper, Lennon, & Whincup, 2007). Older adults also frequently experience a loss of height over time. Owing to these factors, BMI may be a less sensitive indicator of obesity in older adults (Bhurosy & Jeewon, 2013). For this reason, it is recommended that BMI be used together with other measures of fatness such as WC. Therefore, we included both measures in our analyses, as they reflect two important aspects of body composition: overall mass (BMI) and central adiposity (WC). Another limitation of measures such as BMI and WC is that relevant cutoff values for disease risk may vary across populations (Misra et al., 2006; World Health Organization, 2004). To address this, we used cutoff values developed specifically for Asian populations.

The measurement of food insecurity is a complex issue, and many established measures exist (Webb et al., 2006). Using only two questions to assess food insecurity may not capture its multidimensional nature. This approach has generally been used only in high-income countries (e.g., Australia) (Nolan et al., 2006). In the U.S., the Household Food Security Survey Module, which contains 18 items, is favored. The Household Food Insecurity Access Scale (HFIAS) comprises nine generic questions that can be adapted to the relevant population and has regularly been used in disadvantaged communities (Jones, Ngure, Pelto, & Young, 2013). Rather than being a comprehensive food security instrument, the two questions included in the SAGE questionnaire were intended to provide an indication of how food insecurity is linked to other health- and aging-related factors and processes. Despite the limitations of our food insecurity variable, it was strongly and consistently related with socioeconomic factors in the expected direction, which suggests that it may capture important dimensions of disadvantage related to food access. Future studies should examine relationships between socioeconomic factors, food insecurity, and body composition using comprehensive measures of food insecurity.

5.1 | Implications for public health and policy

The National Food Security Act, 2013 (also known as the Right to Food Act) was implemented to provide aid in the form of subsidized food grains to approximately two-thirds

TABLE 4 Odds ratios and 99% confidence intervals from binomial logistic regression models predicting probabilities of elevated waist circumference among older adults in India ($n = 6265$)

Elevated vs normal	Model 1	Model 2
Age	0.99 (0.98, 1.00)[c]	0.99 (0.98, 1.00)[c]
Female	5.19 (4.40, 6.13)[c]	6.04 (4.99, 7.31)[c]
Married	1.21 (1.01, 1.47)[a]	1.13 (0.93, 1.37)
Rural residence	0.46 (0.39, 0.54)[c]	0.61 (0.51, 0.73)[c]
Number of children	1.00 (0.96, 1.04)	0.98 (0.94, 1.02)
Food insecurity (ref = secure)		
Moderately insecure	0.51 (0.39, 0.67)[c]	0.67 (0.50, 0.89)[c]
Severely insecure	0.50 (0.36, 0.68)[c]	0.70 (0.50, 0.97)[a]
Wealth (ref = wealthiest quintile)		
Second Quintile		0.64 (0.51, 0.79)[c]
Third quintile		0.48 (0.37, 0.61)[c]
Fourth quintile		0.38 (0.29, 0.49)[c]
Fifth quintile (poorest)		0.28 (0.21, 0.38)[c]
Education level (ref = high school or higher)		
Less than high school		0.79 (0.61, 1.02)
No formal education		0.67 (0.51, 0.90)[c]
Caste membership (ref = other)		
Scheduled tribe	0.51 (0.36, 0.72)[c]	0.66 (0.46, 0.94)[b]
Scheduled caste	0.57 (0.46, 0.71)[c]	0.72 (0.57, 0.91)[c]
Religion (ref = Hindu)		
Muslim	0.93 (0.73, 1.19)	1.13 (0.88, 1.45)
Other	1.55 (1.03, 2.33)[a]	1.44 (0.95, 2.18)
Fruit intake	1.23 (1.17, 1.39)[c]	1.19 (1.09, 1.29)[c]
Vegetable intake	1.02 (0.93, 1.11)	0.98 (0.90, 1.07)

Ref, referent category.
[a]Statistically significant at $P < .01$.
[b]Statistically significant at $P < .005$.
[c]Statistically significant at $P < .001$

of individuals in India (Sinha, 2013). However, the criteria to qualify for these subsidies are based on household income (Charlton, 2016). As we demonstrate in this study, other dimensions of social disadvantage, such as caste and religion, are associated with food insecurity independently of wealth and education. Along with our results linking food insecurity to underweight, these findings suggest that criteria based solely on household income may be insufficient to identify those who are food insecure or suffer from undernutrition. Our analyses identifying caste and religion as risk factors for food insecurity may help practitioners and policymakers design programs that are more effective at reaching at-risk groups.

5.2 | Implications for life course models of social disadvantage and health

Life course models of social disadvantage and health endeavor to explain how dimensions of social disadvantage, such as those we examine in this study, become biologically embedded and influence health at various stages in the life course (Hertzman, 2012; Leidy, 1996; Willson et al., 2007). Though the deleterious effects of social disadvantage on health in older adults are well documented (Read et al., 2016; Szanton et al., 2010), the mechanisms through which these macrosocial factors "get under the skin" and impact older adult health are not well understood (Hertzman, 2012).

Our results suggest that, among older adults in India, social disadvantage may increase an individual's risk of experiencing food insecurity. Experiences of food insecurity, in turn, may lead to reductions in weight. Underweight is associated with multiple deleterious health outcomes in older adults (Beck et al., 1999; Winter et al., 2014). This suggests that changes in body composition, as a result of food insecurity, may be one process that connects social disadvantage and health in older adults. Further research is needed to examine how social disadvantage across the life course increases an individual's risk of experiencing food insecurity in older adulthood. One possibility is that social disadvantage early in life may decrease access to adequate nutrition, and the lack of access to adequate nutrition may reduce subsequent earning potential through its effects on health. Reduced earnings may then result in further experiences of food insecurity. Repetition of this mutually reinforcing cycle across the life course may result in experiences of food insecurity and poorer health among older adults. Owing to the cross-sectional nature of our study, we are not able to assess the relative contributions of earlier life food insecurity and recent food insecurity to differences in body composition. Additional studies are needed: (1) to examine the effects of food insecurity during critical developmental periods on later life health; (2) to assess the cumulative effects of food insecurity across the life course on health in older adults; and (3) to test whether experiences of food insecurity earlier in life increase an individual's risk of experiencing food insecurity in older adulthood.

5.3 | Conclusion

This study demonstrates that multiple dimensions of social disadvantage—living in poorer households, lower educational attainment, scheduled caste membership, and being Muslim—are associated with food insecurity among older adults in India. Furthermore, our results suggest that those who are food insecure may experience a disproportionately high burden of morbidity and mortality due to greater probabilities of being underweight. In addition, our results from mediation analyses are consistent with the hypothesis that food insecurity may be a mechanism connecting social disadvantage and body composition. These results demonstrate the value of examining culturally salient markers of social status, such as religion and caste, alongside conventional measures, such as wealth and education. Taken together, these findings illustrate pathways through which social inequality may structure disparities in health among older adults in India.

Food insecurity is a daily reality for hundreds of millions of people around the world (The State of Food Insecurity in the World, 2014). The most extreme manifestations of food insecurity are often obvious, but in chronically food insecure communities, identification of households and individuals who experience constraints in their access to food may be less apparent. The present analysis may help policy makers and practitioners better identify older adults at risk for food insecurity and underweight, which may enable more effective targeting of interventions. Our study contributes to the development of life course models connecting social disadvantage, food insecurity, and health, and advances our understanding of how dimensions of the macrosocial environment become biologically embedded and influence health.

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