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Research Article

Social Vulnerability, Frailty, and Their Association With Mortality in Older Adults Living in Rural Tanzania

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Abstract

Background: Social vulnerability correlates with frailty and is associated with mortality and disability. However, few studies have investigated this relationship outside of high-income country settings. This study aimed to produce and analyze a culturally adapted social vulnerability index (SVI) to investigate the relationship between social vulnerability, frailty, and mortality in older adults in Tanzania.
Methods: An SVI was produced using data from a cohort study investigating frailty in older adults in Tanzania. Variables were selected based on previous SVI studies using the categories established by Andrew et al. from the Canadian Study of Health and Aging, and National Population Health Survey. The SVI distribution was examined and compared with a frailty index (FI) produced from the same sample, using mutually exclusive variables. Cox regression survival analysis was used to investigate the association between social vulnerability, frailty, and mortality.
Results: A stratified cohort of 235 individuals were included in the study at baseline, with a mean age of 75.2 (*SD* 11.5). Twenty-six participants died within the follow-up period, with a mean of 503 days (range: 405–568) following the initial assessment. The SVI had a median score of 0.47 (interquartile range: 0.23, range: 0.14–0.86). Social vulnerability significantly predicted mortality when adjusting for age and gender, but not when also adjusting for frailty.
Conclusions: Social vulnerability can be successfully operationalized and culturally adapted in Tanzania. Social vulnerability is associated with mortality in Tanzania, but not independently of frailty.

Keywords: Frailty, Mortality, Social vulnerability index, Sub-Saharan Africa

Frailty is prevalent among older adults and is characterized by reduced physical function and physiological reserve, which leads to diminished resilience to health insults (1,2). Social vulnerability is an overall measure of the social factors comprising one's social circumstances, which may have an adverse effect on health (3,4). Social vulnerability has been operationalized by Andrew et al. (5) using self-reported data from the Canadian Study of Health and Aging (CSHA) and the National Population Health Survey (NPHS). The authors formed a social vulnerability index (SVI) using a deficit accumulation approach (6). Included items represented living situation, social support, social engagement, and perceptions of empowerment and life control. Social vulnerability correlated with age and frailty and was an independent predictor of mortality in older adults (5,7).

In a secondary analysis of the CSHA data, Andrew et al. observed a positive relationship between social vulnerability and mortality for participants with minimal frailty-related deficits (8). This finding was reflected by Armstrong et al. who produced a frailty index (FI) and an SVI for a population of 3 271 Japanese American men aged

over 72 using data from the Honolulu-Asia Aging Study (9). Results indicated that social vulnerability was a predictor of mortality for nonfrail participants but not for participants who were frail or at risk of frailty.

While investigating social vulnerability and frailty in Europe using data from the Survey of Health Ageing and Retirement in Europe (SHARE) study, Wallace et al. found that social vulnerability was a predictor of mortality when controlling for frailty in Mediterranean and Continental countries, but not Nordic countries (10). This difference was attributed to cultural differences in social networks and loneliness. Additionally, the authors suggested that lower social expenditure and gross national product in Mediterranean countries might augment the effects of social vulnerability. This hypothesis is supported by evidence from an SVI study conducted in Mexico, an upper-middle-income country, in which social vulnerability was associated with mortality in older adults when adjusting for age, sex, frailty, and lifestyle factors such as smoking (11).

This research is indicated for several reasons. First, frailty is a significant and increasing global health challenge with a growing prevalence in low- and middle-income countries (LMICs) (12,13). Additionally, within LMICs, Hoogendijk et al. have reported higher rates of frailty for people of lower socioeconomic status (14). The prevalence of frailty in older people in this region of Tanzania has previously been reported in the same study population; 9.25% (95% confidence interval [CI]: 4.39–14.12) when estimated using Fried's frailty phenotype (15), and 19.1% (95% CI: 15.2–23.1) when the Comprehensive Geriatric Assessment (CGA) was used (16). The FI has not previously been operationalized in this context. There is also evidence to suggest important links between social factors and frailty in Tanzania. Qualitative research by Lewis et al. investigating perceptions of frailty in Tanzania found that frailty is often conceived of as being primarily a social, rather than biological problem, as it is exacerbated by challenges such as financial hardship, and difficulty providing familial support (17). Therefore, research investigating the social elements relating to frailty in Tanzania may highlight modifiable social factors which could be addressed by policymakers to improve healthy aging (7).

No previous studies have produced and interpreted an SVI to investigate frailty in a lower-middle-income setting. The aims of this study were to successfully adapt and operationalize an SVI for a community-dwelling population of older adults in Tanzania. Additionally, we aimed to explore whether social vulnerability is an independent predictor of mortality in this population.

Method

This study is a secondary analysis of data collected by Lewis et al. in a longitudinal stratified-cohort study investigating frailty in rural Tanzania (15,16,18). The sample was selected through a process of randomization, using a random number list, from a screened population of 1 207 community-dwelling adults aged ≥60 years. Screening was conducted using a tool developed previously, the Brief Frailty Instrument for Tanzania (B-FIT) (19). The selected sample was weighted to include a higher proportion of frail and prefrail individuals, consisting of 79 nonfrail participants (8.9% of those screened nonfrail), 120 prefrail (42.1% of those screened prefrail), and 36 frail (92.3% of the total screened frail) for whom survey data were available. Full methods for the screening, participant selection, in-depth survey, and CGA data collection process have been published in detail (15,16,18). A Rockwood Clinical Frailty Scale (CFS) score was given based on the CGA (20). Individuals were followed

up systematically until death or the end of the follow-up period, by local enquiries, telephone calls, or home visits, conducted by the village enumerator. Baseline assessments were conducted between the March 17 and August 9, 2017 and deaths or follow-up assessments were recorded up until October 13, 2018.

Participants with cognitive impairment were included in the study, with a close family member providing assent and acting as an informant on behalf of the participant. The research team read aloud the consent form and survey questionnaire, and were trained to provide examples and explanations to ensure participants with sensory impairments or who were unable to read were not excluded from participating. This was in accordance with ethical approvals gained from both local (Kilimanjaro Christian Research Ethics and Review Committee) and national research ethics committees in Tanzania (based at the National Institute for Medical Research, Dar es Salaam), and in the United Kingdom, Newcastle University Research Ethics Committee.

Producing an SVI

Applying the methods of Andrew et al., variables were chosen from the in-depth survey data based on the following social domains (ensuring cross-cultural relevance and adaption where appropriate): communication to engage with the wider community; living situation; social support, engagement, and leisure activities; empowerment and life control; and socioeconomic status (5). The variables represent the general resources, social resources, and social behaviors required for social well-being as described by Bunt et al.'s model of social vulnerability (4). Searle's principles were adhered to, in the development of both SVI and FI (6). The included variables, compared with those included in the CSHA and the NPHS, can be seen in Supplementary Table 1.

Communication to engage in wider society

The number of languages spoken and categories of literacy, from either does not read, reads with difficulty, or reads well, were included (5).

Living situation

Marital status and living alone were variables included in this SVI. Previous research in Tanzania has demonstrated a positive association between marriage, health, and quality of life in older adults (21). Living alone was thought to be particularly important as it is unusual for older people in Tanzania (15), and in the absence of formal social care networks, families are the main providers of care for older adults (22). The proportion of "dependents" living within the household was included, calculated as the number of people aged <18 or >60 divided by total number of household members.

Social support, social engagement, and leisure activities

Variables meeting these domains were taken from the World Health Organization's Study on Global Ageing and Adult Health (WHO SAGE) social engagement questionnaire (23). Higher levels of social engagement, as measured by this questionnaire, are associated with better self-rated health and a higher quality of life in LMICs (23). One question pertaining to the frequency of socializing with coworkers was excluded as there were >5% "nonapplicable" answers. This may be because the majority were not currently working for pay, or because "coworkers" were likely to be other family members working to cultivate family-owned plots of land. Two additional

questions relating to interest in politics and voting were included as a measure of civic engagement (3).

Socially oriented activities of daily living

This section contains 2 variables relating to transport: "To what extent does the participant have problems using transport?" and "How much do difficulties with transport restrict the participant's life?" A mixed-methods study in rural Tanzania has shown that transport challenges may be a barrier to accessing health care, with walking and motorcycle taxis being the main forms of transport in rural villages (24). Costs of transport, as well as symptoms of back pain and fatigue, were factors that limited older adults' travel, yet ease of accessing transport is likely to be particularly important in a setting where older adults daily activities are reliant on walking in order to collect water or firewood (24).

Empowerment and life control

The Quality of Life Scale (CASP-19) questionnaire, which includes 19 Likert-scale questions in the domains of control (C), autonomy (A), self-realization (S), and pleasure (P), was employed (25). The questionnaire was developed in a European setting but has been cross-culturally validated and used in several international settings, including in Ethiopia (26,27).

Two questions were taken from the Duke University Religion Index questionnaire, analyzing religiosity (28). The questions selected measure intrinsic religiosity ("I try hard to carry my religion over into all other dealings in life"), and nonorganizational religious activity ("How often do you spend time in private religious activities, such as prayer, meditation or Bible study?") given that participation in organized religious activities may be limited for the physically frail (28). The variable "thoughts about religion" was included in the SVI by Andrew et al. (5) and the literature suggests that religion is a positive social determinant of health, potentially through providing social connection and promoting healthy lifestyle choices (29,30). Religious belief was thought to be contextually relevant in a lower-middle-income country such as Tanzania, as demonstrated by Zimmer et al. who found a very diverse relationship between religious participation and belief with self-reported health, but demonstrated a trend toward a more positive association in countries with lower human development indices (31).

The final variable describes fear of crime or violence at home. It was suggested for inclusion in the Mexican SVI study and reflects both the home situation and neighborhood of the individual (11). Frailty has been shown to be more strongly associated with fear of crime than chronological age in an analysis of the WHO SAGE surveys of LMICs, which was an important reason for its inclusion (32).

Socioeconomic status

Formal social support is provided for a minority of older adults in Tanzania, with 3.2% of the statutory pension-age population receiving a pension (33). Given the prior finding that frailty has been conceived of as primarily a social problem, hallmarked by financial insecurity (17), we included the following questions: "Does the participant receive a pension?" and "Is the participant completely financially/materially dependent on family?"

Other variables relate to food insecurity, which is prevalent throughout Tanzania and is associated with multimorbidity as well as increased health care use (34). For example, "In the last 12 months, were you ever hungry, but didn't eat because you couldn't afford enough food?" was a question taken from the WHO SAGE individual questionnaire (35).

Questions relating to the home and possessions were also included as measures of socioeconomic status, for example, access to electricity in the home (the proportion of the rural population with electricity access is 16.9%) (33). Estimating annual or monthly household earnings can be very challenging where income is through informal employment or dependent on seasonal harvests.

Coding

Each variable was coded between 0 and 1, with 0 indicating no deficit and 1 indicating the highest level of deficit (see Table 1). For instance, a binary variable such as receipt of a pension would be coded 0 if the participant had a pension, and 1 if they did not. Alternatively, an ordinal variable such as attendance at social events would be coded 1 for never, 0.75 for once or twice per year, 0.5 for once or twice per month, 0.25 for once or twice per week, and 0 for daily. This approach has been used in previous research in this field (3,11). The total deficit score for each participant was then summed and divided by the total number of variables ($N = 48$) to produce an SVI between 0 and 1.

Frailty Index

An FI was produced using 37 variables from the following 5 domains; function, cognition and mood, comorbidity, health attitudes, and physical performance (6,36). The variables used for the FI and the SVI were mutually exclusive. Details of the variables and their coding have been included in Supplementary Table 2.

Statistical Analysis

Data analysis was conducted using IBM SPSS statistics version 27. Histograms, normality plots, and tests were used to examine the distribution of the SVI. Patterns of missing data were analyzed using data visualization and Little's missing completely at random (MCAR) test. Data missing not at random were imputed using conditional mean imputation based on participants of the same gender and age group. The correlations between SVI, FI, and age were plotted using scatter graphs and assessed using Spearman's rank correlation coefficient to determine construct validity. The Mann–Whitney test was used to investigate the relationship between SVI and sex, as well as factors of interest such as mobility. A receiver operating characteristic (ROC) curve was produced to discern the discriminative ability of the SVI to predict mortality. Cox survival regression analysis was used to analyze the relationship between social vulnerability and mortality. For this analysis the explanatory variable was the total number of deficits (the raw SVI score before dividing it by the number of variables), and the dependent variable was "weeks before death or follow-up." Crude and adjusted hazard ratios were calculated with adjustment for the independent variables age, gender, and total number of SVI deficits in the first model, and additionally the total number of FI deficits in the second model.

Results

Missing Data

One participant was excluded from the FI analysis as 22 out of 37 FI variables were missing. Therefore, 234 participants were included in the FI analysis. Overall, 0.76% and 0.79% of data were missing for the SVI and FI variables, respectively, and no variable was missing more than 5% of responses. SVI and FI missing data were not missing at random (SVI data; Little's MCAR test Chi^2 = 687.315, df = 610, Sig = 0.016 and FI data; Little's MCAR test Chi^2 = 308.891, df = 253,

Table 1. Social Vulnerability Index Items and Coding

Variable	Scoring
Communication to engage in wider community	
Number of languages spoken, for example, Kichagga, Kiswahili	1: 1 language, 0: 2 languages
Literacy	1: does not read, 0.5: finds reading difficult, 0: reads well
Living situation	
Marital status	1: single/divorced/widowed/separated, 0: married
Lives alone?	1: yes, 0: no
Percentage of dependents within the household	Number of people aged under 18 or over 60 divided by total number of household members
Social support, social engagement, and leisure activities	
Items from WHO SAGE social integration questionnaire: attending public meetings, meeting community leaders, attending groups, working with the neighborhood to fix something, having friends over, socializing with people from different neighborhoods, attending social events, leaving the house for social reasons.	1: never, 0.75: once or twice per year, 0.5: once or twice per month, 0.25: once or twice per week, 0: daily
One item regarding socialization with coworkers was excluded due to lack of applicability to an older population	
Interest in politics and national affairs	1: very uninterested, 0.75: uninterested, 0.5: neither interested nor uninterested, 0.25: interested, 0: very interested
Did you vote in the last national election?	1: no, 0: yes
Socially oriented activities of daily living	
To what extent do you have problems with using transport?	1: extreme or cannot do, 0.75: severe, 0.5: moderate, 0.25: mild, 0: none
How much do difficulties with transport restrict your life?	1: extreme or cannot do, 0.75: severe, 0.5: moderate, 0.25: mild, 0: none
Empowerment and life control	
All items from the CASP-19 (control, autonomy, self-realization, and pleasure) quality of life questionnaire	CASP items 1, 2, 4, 6, 8, 9:
	1: often, 0.67: sometimes, 0.33: not often, 0: never
	All other CASP items:
	1: never, 0.67: not often, 0.33: sometimes, 0: often
How often do you spend time in private religious activities, such as prayer, meditation, or Bible study?	1: rarely or never, 0.75: few times a month, 0.5: once a week, 0.25: 2 or more times per week, 0: daily or more
I try hard to carry my religion over into all other dealings in life	1: definitely not true, 0.75: tends not to be true, 0.5: unsure, 0.25: tends to be true, 0: definitely true
In general, how safe from crime and violence do you feel when you are alone at home?	1: not safe at all, 0.75: slightly safe, 0.5: moderately safe, 0.25: very safe, 0: completely safe
Socioeconomic status	
What is your highest level of education?	1: no formal schooling, 0.8: some primary school, 0.6: primary school, 0.4: secondary school, 0.2: university, 0: postgraduate studies
Do you receive a pension?	1: no, 0: yes
Are you completely financially/materially dependent on family?	1: yes, 0: no
How many meals do you eat per day?	1: struggles to find a meal, 0.67: 1 meal, 0.33: 2 meals, 0: 3 meals
In the last 12 months, were you ever hungry, but did not eat because you could not afford enough food?	1: every month, 0.75: almost every month, 0.5: some months, but not every month, 0.25: only in 1 or 2 months, 0: never
How many days per week do you eat meat?	1: 0–1 days, 0.67: 2–3 days, 0.33:4–5 days, 0: 6–7 days
Does your home have electricity?	1: no, 0: yes
Does anyone in your household have a motorbike?	1: no, 0: yes
Does anyone in your household have a mobile/cellular telephone?	1: no, 0: yes

Note: WHO SAGE = World Health Organization's Study on Global Ageing and Adult Health.

Sig = 0.009). Participants who were missing data for the SVI and FI were significantly more likely to be older ($U = 6065$, $p = .002$) and frailer ($U = 5786$, $p = .009$). The variable responses (frequencies and percentages) are displayed in Supplementary Tables 3 and 4.
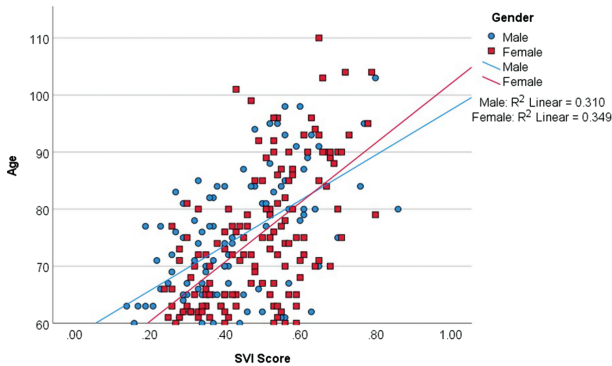
Figure 1. Scatter graph of the correlation between age and social vulnerability index (SVI) score by gender. Full color version is available within the online issue.
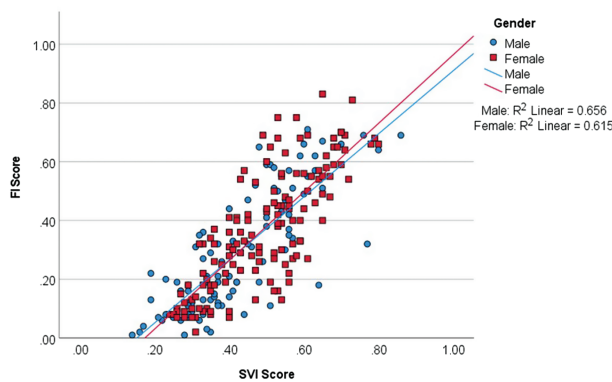
Figure 2. Scatter graph of the correlation between social vulnerability index (SVI) score and frailty index (FI) score by gender. Full color version is available within the online issue.

The sample demographics are described in Supplementary Table 5. The mean age was 75.2 (*SD* 11.5), and 137 (58.3%) were women. A third of participants could not read 79 (33.6%), and 71 (30.2%) had received no education.

The median score for the SVI was 0.47 (interquartile range [IQR]: 0.23, range: 0.14–0.86). The FI had a median score of 0.32 (IQR: 0.35, range: 0.01–0.83). The SVI had a bimodal distribution, while the FI distribution was positively skewed (see Supplementary Figures 1 and 2).

When stratified by sex, the median SVI score was significantly higher for women than for men ($U = 8503.5$, $p < .001$). Women had a median SVI score of 0.51 (IQR = 0.20), whereas the male median SVI score was 0.40 (IQR = 0.24). Social vulnerability was also significantly higher in participants with mobility problems ($U = 9276$, $p < .001$). Participants from households owning a motorbike were significantly less socially vulnerable ($U = 3667.5$, $p = .023$).

Social vulnerability correlates with age and measures of frailty, including scores such as the B-FIT and the CFS, and phenotypic frailty indicators such as walking speed and body mass index (18,37). These correlations have been presented in scatter graphs to demonstrate construct validity (see Figures 1 and 2). Spearman's rho test demonstrated that social vulnerability correlates significantly with age and frailty status (Table 2). The strongest positive correlation with the SVI was with frailty measured by FI (Spearman's rho = 0.809; $p < .005$), while the B-FIT screening tool was also positively correlated (Spearman's rho = 0.521; $p < .005$).

Mortality

By the end of follow-up, 204/235 participants (86.8%) were still alive, 26 (11.1%) had died (of whom 22 were frail), 4 (1.7%) had moved away, and 1 (0.4%) had withdrawn from the study. The mean follow-up period was 503 days (range: 405–568); mean time to death was 280 days (range: 5–520). Cox survival regression analysis was performed to investigate the associations between social vulnerability, frailty, and mortality (Table 3). In the first model, social vulnerability was significantly associated with mortality when adjusting for age and gender. There was a 1.13 increase in the death hazard for each additional deficit in the SVI.

Table 2. Spearman's Rho Correlations Between SVI Score, Age, and Frailty Scores for the 235 Community-Dwelling Older Adults Living in Rural Tanzania

	Age	CFS Score	FI Score	B-FIT Score
SVI score	0.537*	0.767*	0.809*	0.521*

Notes: B-FIT = Brief Frailty Instrument for Tanzania; CFS = Clinical Frailty Scale; FI = frailty index; SVI = social vulnerability index.
*Significance level, $p < .005$.

Table 3. Cox Survival Regression Analysis Investigating the Association Between Social Vulnerability, Frailty, and the Hazard Ratio (HR) for Mortality for the 235 Community-Dwelling Older Adults Living in Rural Tanzania

	Model 1			Model 2		
	HR	95% CI	*p* Value	HR	95% CI	*p* Value
SVI (deficit count)	1.133	1.056–1.215	.001**	1.058	0.967–1.157	.218
Age (years)	1.041	1.002–1.081	.04*	1.034	0.994–1.076	.099
Gender	1.300	0.596–2.832	.510	1.418	0.645–3.116	.385
FI (deficit count)	—	—	—	1.109	1.015–1.212	.022**

Notes: FI = frailty index; SVI = social vulnerability index. Model 1: adjusted for age and gender. Model 2: adjusted for age, gender, and FI deficit count.
*$p < .05$. **$p < .005$. Bold indicates significance level.

In the second model, the FI was adjusted for, in addition to age and gender. Significance for the SVI was lost following adjustment for frailty.

ROC Analysis

ROC analysis demonstrated that social vulnerability was a significant predictor of mortality. The area under the ROC curve was 0.808 (95% CI: 0.722–0.893; see Supplementary Figure 3).

Discussion

Social Vulnerability and Frailty in Tanzania

SVI distribution

The median SVI score at 0.47 (IQR: 0.23) was higher in this population than in other settings (5,9,10). This result is likely due in part to the adverse social factors that have been described, such as low pension coverage. However, these results must be interpreted with caution, as the study sample is frailty-weighted which may have inflated the proportion of socially vulnerable participants.

The SVI had a minimum score of 0.14, which indicates that all participants experienced some degree of social vulnerability. This is a regular finding within SVI studies (5,9). The FI had a minimum score of 0.01 as all participants experienced at least 1 frailty-related deficit. The Mexican SVI study also had no participants without frailty-related deficits (11). These findings contrast with SVI studies conducted in high-income settings in which some participants have no frailty-related deficits; however, these findings may again be due to sample selection (5).

The distribution of the SVI is bimodal. The SVI distribution differs throughout studies but generally trends toward a normal distribution (5,9,10). The bimodal distribution of the SVI found in these data may either represent a true finding in the distribution of social vulnerability in this population, or may suggest 2 groups of participants, rather than 2 constructs of the SVI. The 2 groups may be related to the sampling method, which was weighted toward more physically frail individuals, so that the more socially vulnerable may have been grouped together by their common difficulties with mobility, and thus with social engagement. Many social events occur in the community and participants who are unable to access these events due to problems such as mobility, illness, or transport issues may gain particularly high scores within this SVI domain. Further analysis such as exploratory factor analysis should be conducted with larger, more representative populations in order to elucidate this further. The FI displayed a right-skew which is the standard distribution for an FI (6). The difference in distribution between the FI and the SVI suggests that they are distinct constructs.

Trends

Women experienced greater social vulnerability than men. Another study in rural Tanzania investigating quality of life in older adults observed a similar trend, in which older women reported a lower quality of life than older men (21). This trend is also reflected by SVI studies in different settings, such as France and Canada (5,7). A similar phenomenon occurs in frailty, wherein women have higher FI scores despite improved survival (38). Older women are more likely to face increased exposure to adverse social factors such as food insecurity or reduced educational opportunities (39). In Tanzania, women are also less likely to inherit land when widowed, which may affect financial stability in later life (40). As social vulnerability and frailty are significantly correlated and share risk factors, higher frailty in women may cause higher social vulnerability; however, the nature of this association should be further explored, including in other LMIC settings.

People who experienced mobility problems also experienced significantly higher social vulnerability. Immobility is likely to have a higher impact on social vulnerability in rural Tanzania, where walking is the main mode of transport, and people have lower access to resources such as mobility aids and accessible public transport (24).

Relationship Between Social Vulnerability, Frailty, and Adverse Outcomes

Correlations

Social vulnerability correlated strongly with age and measures of frailty. Social vulnerability was more strongly correlated with the FI (produced from in-depth survey and anthropometric data) and the CFS (graded based on the CGA), than the B-FIT screen. This may be because both the FI and CFS described a more multidimensional measure of frailty, including aspects such as mood and nutrition, in keeping with consensus expert opinion (36). However, the version of the B-FIT employed in this study included 2 domains; a measure of cognition and activities of daily living (19). Later work to improve the sensitivity and specificity of the B-FIT for identifying frailty led to the inclusion of additional variables; calf circumference, ability to join in with social activities, and poor distance vision (18). These results also suggest that future work should employ more multidimensional measures of frailty, such as the adapted version of the B-FIT screen (18).

Mortality

The ROC curve showed that social vulnerability is a good predictor of mortality, which is an indicator of criterion validity for the SVI. This result was reiterated by the Cox regression model which demonstrated an association between social vulnerability and mortality when controlling for age and gender. However, significance was lost following adjustment for the FI, which suggests confounding by the SVI, and that frailty is a stronger predictor of mortality than social vulnerability. This result disproves the hypothesis that the impact of social vulnerability on mortality would be independent of frailty in Tanzania, as it was for Mediterranean countries in the SHARE study and in the Mexican SVI study (10,11). There are several potential reasons for this result.

First, there are considerable social differences between the Mediterranean countries, Mexico, and Tanzania which may mean that social vulnerability does not have the same impact. For instance, Wallace et al. noted that participants in Mediterranean settings lacked social support and social networks besides family, compared to the Nordic and Continental countries that had higher formal social support networks and more civic engagement, and theorized that this difference might increase the impact of social vulnerability (10). In contrast, informal social support is more common in Tanzania and people are more interdependently connected with others in the community (17,41). This social model is likely to have more in common with Mexico and other LMICs, for example, Tanzania, similar to Mexico has higher levels of income and health inequality as compared with many higher-income countries (33).

Another possibility is that the Tanzanian sample is highly socially vulnerable due to high levels of poverty and low indicators of human development (33,42). Most of the study sample were of lower

socioeconomic status, as indicated by the low prevalence of home electricity and motorbike ownership. It is possible that social vulnerability is not associated with mortality independently of frailty in this setting, because social vulnerability is more common and therefore does not differentiate between participants with an increased risk of mortality. Additionally, it is possible that the most socially vulnerable people in this resource-limited setting do not reach older age, which might paradoxically limit the relationship between social vulnerability and mortality in older adults. This effect was theorized in a study of mortality in older adults in this district of Tanzania, which found a lower age-standardized mortality rate than was estimated for United Kingdom for adults aged over 70 years (43).

Other SVI studies such as the Honolulu-Asia Aging Study and Canadian study by Andrew et al. demonstrated a positive association between social vulnerability and mortality in participants who were not frail in adjusted models, but no significant association for those who were frail (8,9). The Honolulu-Asia Aging Study results demonstrated that social vulnerability was a strong predictor of death for fitter older adults, but not for older adults who were experiencing frailty-related health deficits (9). It was presumed that this result occurred because preexisting and intrinsic health problems were likely to affect mortality more strongly than extrinsic social factors (9). It is possible that this trend is also present in Tanzania but the relatively small sample size and high frailty prevalence means a subanalysis was not possible.

Finally, very few older people live in institutions in Tanzania. This is important as it means that this community-dwelling sample will have included all those with severe frailty and terminal illness that might in high-income countries be admitted to institutional care. This factor may have skewed the frailty-weighted sample toward more severe frailty. These factors in the study design may have led to a bias toward a strengthened association between frailty and mortality compared with other studies.

Cultural Context and Adaption

The original SVI was designed using nationally representative Canadian data, and this study has attempted to cross-culturally adapt the tool for rural Tanzania. There are many cultural and contextual differences which have made adaption important and may have contributed to differences in our results, compared to other settings.

Skirbekk et al. estimate that in 2010, a minority of 3.6% of older people in sub-Saharan Africa (SSA) had no religious affiliation, compared to 10% in North America and 15% in Europe (44). In this study, all older participants described a religious association. This was hypothesized to be a particularly important aspect of social well-being, and conversely of social vulnerability in this setting (30). Yet previous epidemiological work investigating religious participation as a health determinant has found mixed effects on mortality (29). The Health and Retirement Study in the United States found that frequent participation in religious activities may be protective partially, but not fully, mediated by better health behaviors and improved social ties. However, reporting that religion "was very important" increased the hazard ratio for mortality, mediated by worse health (29). That is, religion became more important for those that were in poor health and closer to the end of life (29). The variables included in our study measured intrinsic belief and nonorganizational religious activity in order to avoid confounding by impaired mobility or difficulty accessing transport, which would have stopped older people with frailty from regularly attending a place of worship. As a

result, it is unclear whether answering positively should be counted as a social deficit or viewed as protective.

Food insecurity was thought likely to be an important component of social vulnerability in rural Tanzania (34). However, unintentional weight loss is also described by Fried et al. as part of the phenotype of frailty (45). While no variables were overlapping between the SVI and FI, the fact that nutritional measures were deemed relevant for both constructs means that proxy markers of undernutrition were included in the FI (through calf circumference and midupper arm circumference measures). Additionally, the SVI included the related proxy measures of socioeconomic status; self-reported hunger over the previous 12 months, meals per day, and frequency of eating meat (a higher-cost food item). The relatedness of these variables, might help explain the confounding effect of the SVI for mortality, revealed when adjusting for FI. It also highlights the challenge of developing a truly independent SVI and FI from the same data set, particularly when taking a multidimensional approach to frailty (36).

Applications of Social Vulnerability in Tanzania

This study demonstrates that the SVI can be successfully operationalized in Tanzania and may be a helpful construct in LMICs. There are many potential applications for social vulnerability, for example, the SVI could be used to identify socially vulnerable people who may gain health benefits from social interventions. Interventions such as low-cost social engagement programs may be particularly beneficial in low-resource settings (46). Further analysis of the SVI could help to identify factors predisposing individuals to social vulnerability, such as mobility problems, and lead to relatively low-cost and high-impact interventions, such as the provision of walking aids. Social inequalities resulting in adverse social factors such as food insecurity, and financial dependence could be improved through upstream social policy changes, such as increasing the availability of pensions (47). The SVI could be used to examine modifiable social determinants of health and to inform health and social policy in order to reduce health inequalities, particularly when taking a life-course approach to healthy aging (48).

Strengths

This is the first work to develop, and cross-culturally adapt, an SVI to investigate frailty, social vulnerability, and their association with mortality in a lower-middle-income country in SSA. The data set allowed the inclusion of several well-considered variables covering a variety of social domains. This study leads the way in a promising research area that could have a significant influence on policies for the promotion of healthy aging in LMICs.

Limitations

As with most SVI studies, this research used secondary data which is a limitation as the SVI design is constrained to the data collected (5). Data were mostly reliant on self-report, whereas SVI studies in high-income settings may employ community deprivation level data (3). The results are also limited by a smaller sample size and shorter follow-up period compared to other SVI studies (5,8–11). Furthermore, the sample is frailty-weighted which, as discussed, may artificially inflate the proportion of socially vulnerable participants, making direct comparison with other studies more difficult. Data were not missing at random; however, this has been addressed through conditional mean imputation. This limitation is prevalent throughout SVI studies which often observe that older and more frail participants are more likely to have missing data (3,5). While

variables selected for the SVI and FI were mutually exclusive, some variables may have been measuring similar effects, for example, for undernutrition as a marker of both physical frailty and lower socioeconomic status. The items included in the SVI were not assessed for internal consistency during this study, but several questionnaires used such as the CASP-19, and the WHO SAGE social engagement questionnaire has been shown to have acceptable internal consistency.

Though social vulnerability is highly prevalent and important in this sample it is unclear to what extent this can be easily extrapolated to the rest of Tanzania. The Kilimanjaro region, where this study was carried out, is a largely rural area of medium human development, whereas most regions of Tanzania are poorer, equating to areas of low human development (42). A larger sample, inclusive of different socioeconomic groups, and both rural and urban-dwelling older people, would help examine the impact of socioeconomic inequality on social vulnerability and other health-related outcomes.

Conclusion

Social vulnerability prevalence is high among a frailty-weighted population of community-dwelling older adults in rural Tanzania. Women experience more social vulnerability than men. Social vulnerability is associated with mortality, but not when adjusting for frailty. The SVI strongly correlates with age and frailty, indicating construct validity. Overall, these findings indicate that social vulnerability is a valid construct in the context of Tanzania. These findings suggest that the SVI can be cross-culturally adapted and operationalized successfully in a lower-middle-income country in SSA.

Future work should investigate the SVI with a larger and more representative Tanzanian population for a longer follow-up period. Short screening tools for social vulnerability could be developed, as have been produced in settings such as Japan, to identify individuals at higher risk of mortality and disability (49). Future larger studies may also investigate potential interventions and the impacts of policy changes on social vulnerability and health.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

Conflict of Interest

None declared.

Author Contributions

F.C., E.G.L., C.D., W.K.G., S.U., and R.W.W. were involved in the study's conception, design and analysis. F.C. and E.G.L. led the drafting of the paper. L.W., H.C., S.C., G.K.W., D.M., J.M., and F.Z. contributed to editing the paper and to data collection. All authors approved the final submitted version.

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