THE GERONTOLOGICAL SOCIETY OF AMERICA®

Innovation in Aging
cite as: *Innovation in Aging*, 2018, Vol. 2, No. 3, 1–8
doi:10.1093/geroni/igy037
Advance Access publication December 15, 2018

OXFORD

Original Report

Social and Economic Predictors of Worse Frailty Status Occurrence Across Selected Countries in North and South America and Europe

Cristiano dos Santos Gomes, PhD,[1] Ricardo Oliveira Guerra, PhD,[1] Yan Yan Wu, PhD,[2] Juliana Fernandes de Souza Barbosa, PhD,[1] Fernando Gomez, MD,[3] Ana Carolina Patrício de Albuquerque Sousa, PhD,[4] and Catherine M. Pirkle, PhD[2,*]

[1]Department of Physiotherapy, Universidade Federal do Rio Grande do Norte, Natal, Brazil. [2]Office of Public Health Studies, University of Hawai'i at Mānoa, Honolulu, Hawaii. [3]Research Group in Geriatrics and Gerontology, Faculty of Health Sciences, Universidad de Caldas, Manizales, Colombia. [4]Multicampi Medical Sciences School, Universidade Federal Do Rio Grande Do Norte, Caicó, Brazil.

*Address correspondence to: Catherine M. Pirkle, PhD, Office of Public Health Studies, University of Hawai'i at Mānoa, 1960 East-West Road, BioMed T102, Honolulu, HI 96822-2319. E-mail: cmpirkle@hawaii.edu

Received: March 16, 2018; Editorial Decision Date: November 7, 2018

Decision Editor: Laura P. Sands, PhD

Abstract

Background: Frailty, a state of vulnerability to poor resolution of homoeostasis after a health stressor, may be a result of cumulative decline in many physiological systems across the life course and its prevalence and incidence rates vary widely depending on the place and population subgroup.
Objective: This study aims to examine social and economic factors as predictors of worse frailty status over 2 years of follow-up in a sample of community-dwelling older adults from the International Mobility in Aging Study.
Methods: We analyzed 2012 baseline and 2014 follow-up (n = 1,724) data on participants from a populational-based, longitudinal study conducted in 4 countries (e.g., Brazil, Colombia, Albania, and Canada). Frailty was defined according to the Fried's phenotype and Poisson regression models with robust standard errors were performed to estimate the relative risks of becoming frail.
Results: In our study, 366 (21.2%) participants migrated to a worse stage of frailty. After statistical adjustment (e.g., participant age, sex, and study site), insufficient income (RR = 1.40; 95% CI = 1.00–1.96) and having partner support (RR = 0.80; 95% CI = 0.64–1.01) were predictors of incident frailty status.
Conclusion: Notably, transitions in frailty status were observed even in a short range of time, with sociodemographic factors predicting incident frailty.

Translational Significance: Results suggest that frailty may be delayed or prevented with policies that support older adult income sufficiency and interpersonal relationships, especially partner support.

Keywords: Frailty, Incidence, Older adults

Frailty, defined as a state of vulnerability to poor resolution of homoeostasis after a health stressor, may be a result of cumulative decline in many physiological systems across the life course (Clegg, Young, Iliff, Rikkert, & Rockwood, 2013). It is one of the most problematic expressions of aging because relatively minor stressor events can result in sudden health status changes, including delirium, disability, and death (Clegg et al., 2013). This state of vulnerability is often measured by applying a physical frailty definition proposed by Fried and colleagues (2001), which considers the following conditions: weakness, unintentional weight loss, self-reported exhaustion, low physical activity, and slow walking speed. Fried's definition is quoted as the most used in studies to estimate the prevalence of frailty in community dwelling older people (Collard, Boter, Schoevers, & Oude Voshaar, 2012).

Prevalence and incidence rates of frailty are variable according to characteristics, such as age, sex, and country of study (Choi, Ahn, Kim, & Won, 2015). For instance, data from low and middle-income countries (LMICs), that included data from Brazil and Colombia, estimated the prevalence of frailty at 11.1% for men and 15.2% for women using Fried's definition of frailty (Siriwardhana, Hardoon, Rait, Weerasinghe, & Walters, 2018), while in high income countries such as Canada, this prevalence was lower at around 6.2%, with females being more likely to be frail than males (Kehler et al., 2017).

These differences in frailty prevalence may be interpreted from the perspective of cumulative advantage/disadvantage and life-course theory (Dannefer, 2003), in which overall socioeconomic deprivation negatively affects health. It would be expected that people from relatively deprived settings, like Brazil and Colombia, would experience more adversity over their lifetime than those from Canada, which is wealthier. Previous cross-sectional studies have shown that frailty is associated to socioeconomic inequalities (low education or income) in both high, middle, and low income countries (Hoogendijk et al., 2018; Szanton, Seplaki, Thorpe, Allen, & Fried, 2010). However, it remains unknown if similar inequality patterns could be related to frailty transitions across settings with diverse economic profiles.

Previous research from diverse global populations suggests that the long-term effects of social and economic adversities during childhood can influence health conditions in later life, for example, research from Canada, Latin America, and Europe report associations between domestic violence experiences, socioeconomic disadvantages in early life, and adolescent childbirth with low mobility, poor locomotor and physical function, cognitive decline, and frailty in elderly populations (Alvarado, Zunzunegui, Béland, & Bamvita, 2008; Barnes et al., 2012; Birnie et al., 2011; Guedes et al., 2016; Pirkle, de Albuquerque Sousa, Alvarado, Zunzunegui, & IMIAS Research Group, 2014). Physical function declines and loss of mobility are associated with frailty (Eeles & Low Choy, 2015) and it is likely that factors influencing these outcomes, such as early life adversities, are also associated with frailty.

Research on frailty predictors often does not concomitantly consider early-life and adult adversities. While poor economic status (Phillips, Auais, Belanger, Alvarado, & Zunzunegui, 2016) and limited social ties and support (Bélanger et al., 2016) in adulthood appear to negatively influence older adult health outcomes, there is also evidence that adversity during the critical developmental period of early life may independently influence health outcomes in later life, contributing to greater overall morbidity and early onset of poor health outcomes (Sousa, Guerra, Tu, & Patrı, 2014). Thus, it is possible that early life adversities may contribute to earlier onset of frailty independently from adulthood adversity measures, but this is relatively unexplored in the literature. Further, the magnitude and nature of adversity experienced across the life-course may differ across world regions, with people from poorer countries experiencing, in general, greater and more severe adversity.

To further knowledge about frailty syndrome, we hypothesized that the frailty concept is dynamic over time and that social and economic conditions can be associated with frailty incidence, specifically contributing to transitions to worse frailty status over time. Thus, we aimed to (1) document the frequency of frailty transitions from countries with diverse economic profiles among older adults in a 2-year period of time and (2) examine social and economic adversities as predictors of worse frailty status in this diverse sample.

Research Design and Methods

Context

The International Mobility in Aging Study (IMIAS) is a population-based longitudinal cohort study conducted in five cities in four countries (i.e., Natal in Northeast Brazil; Manizales, in the Andean coffee region of Colombia; Tirana, the capital of Albania; Kingston and Saint-Hyacinthe in Ontario and Quebec, Canada, respectively; Gomez et al., 2018). The sites selected represent varied ways of living in very diverse societies with very different demographic, health, and economic indicators. For example, the percentage of older adults in 2015 varied from 7% in Colombia to 16% in Canada (Gomez et al., 2018). Life expectancy ranges from 64 (Albania and Brazil) to 73 years (Canada) across study sites. Further, gender disparities vary considerably across these sites, with Canada having the lowest gender inequality index (18) compared to Brazil (92; Gomez et al., 2018). In relation to differences in health systems in IMIAS sites, the Universal Health Care index ranged from to 62 (Albania) to more than 80 (Canada), and health expenditure was lower in Albania ($244.00 per capita), Colombia ($284.00 per capita), and Brazil ($606.00 per capita) compared with Canada ($4409.00 per capita; Gomez et al., 2018). Thus, the IMIAS population provides a good opportunity to investigate the influence of a diverse array of early life and adulthood social and economic adversities on the frailty status of older adults. This is a prospective analysis using data from the baseline and 2 years of follow up of the IMIAS Study.

Assessments

Interviewers received a standard training at each study location using videotapes, protocol instructions, and data entry forms. Assessments in Tirana were done by public health professionals and graduate students, in Natal by physiotherapists, in Manizales by local nurses, in Kingston and in Saint Hyacinthe by teachers and other lay professionals. The questionnaires, all data collection documents and procedures manuals were available in the local languages. French, Portuguese, and Spanish versions of the main scales were validated in two pilot studies conducted in Brazil, Colombia, and Quebec (Gomez et al., 2018).

Instrument and Measures

Dependent variable

Physical frailty

For our outcome measure, we employed the physical frailty definition proposed by Fried and colleagues (2001). *Weakness* was defined by the assessment of handgrip strength using a hand-held dynamometer (Jamar Hydraulic Hand Dynamometer). The reliability of the HGS test measured using intra-class correlation has been excellent (ICC > 0.90; Schrama, Stenneberg, Lucas, & van Trijffel, 2014). The cut offs used for the analyses were <26 kg for men and <16 kg for women (de Souza Barbosa et al., 2016). *Weight loss* was defined using the following yes or no self-reported question: Have you lost 5 kg (10 lbs.) or more unintentionally in the last 12 months? *Exhaustion* was considered present if the participant responded affirmatively to either of the following Center for Epidemiological Scale-Depression (CES-D) questions: "Felt that everything I did was an effort in the last week" or "Could not get going in the last week" (Batistoni, Neri, & Cupertino, 2007). The *Mobility Assessment tool for Walking* (MAT-W) was used to define low physical activity. The test–retest reliability of MAT-W was excellent (intraclass correlation coefficient > .85). The MAT-W was correlated with mCHAMPS5 (Spearman $r = .66$, $p < .001$) and moderate/vigorous levels of physical activity as assessed by accelerometry (Spearman $r = .65$, $p < .001$; Marsh et al., 2015). Low physical activity was defined as falling into the lowest 20% of the distribution for total weekly walking time for the total population (less than 60 min/week). Lastly, *gait speed* was measured by asking the participant to walk at his/her usual pace 4 m; the test was performed twice and the fastest speed was used for the analyses. Slow walking speed was defined as the lowest quintile of the gait speed distribution adjusted by site, sex, and median of height in a 4-m test.The 4-m gait speed test has excellent test–retest reliability (ICC = 0.96) and agreement when compared with the 10-m walk test (ICC = 0.93) in healthy older adults (Schrama et al., 2014). Those who did not present any of the aforementioned conditions that constitute the frailty definition were classified as nonfrail, those who presented 1–2 were classified as prefrail and those with 3 or more were defined as frail.

The independent predictive validity of this frailty phenotype was previously evaluated by its prospective association with five important adverse health outcomes (i.e., incident falls, worsened mobility or ADL disability, incident hospitalization, and death), ascertained in prospective follow-up using Cox proportional hazards models. Associations were significant ($p < .05$) over 3 or 7 years (Fried et al., 2001). This definition of frailty was previously applied in the IMIAS study population (dos Santos Gomes et al., 2018). Later, for our models with a dichotomous outcome variable, we considering the people who were nonfrail in 2012 and remained nonfrail in 2014 as "robust" and categorized the subjects who were nonfrail in 2012 but transitioned to prefrail or frail category in 2014 as "worse frailty status."

Independent variables

Demographic variables

The participant's age was self-reported. Study site and sex were recorded by the trained interviewer.

Life-course adversity measures

Childhood adversity circumstances were evaluated based on two clusters of "yes" or "no" questions selected by explanatory factors analysis with oblimin rotation: social and economic adversities before 15 years of age (Sousa, Guerra, Tu, Patrı, et al., 2014). Social adversities included: parental drinking or drug use, witnessing physical violence, and having been physically abused. Childhood poverty, hunger and parental unemployment were clustered as economic adversities (Sousa, Guerra, Tu, Patrı, et al., 2014). An affirmative response to any of the items listed above resulted in a point, with social and economic adversity scores ranging from 0 to 3 (Sousa, Guerra, Tu, Patrı, et al., 2014). Those categories were later split in two categories of 0–1 adversities and 2–3 adversities; those in the second category were considered to have experienced important early life adversities.

Total years of education was divided in three categories according to site-specific tertiles of high, medium, and low education. It is possible for a participant to have high educational attainment relative to his/her community, but medium or low attainment compared with another site in IMIAS (Hwang et al., 2017). Low education is considered as an indicator of adversity across the life course.

Lifetime occupation was classified according to the International Standard Classification of Occupation and participants were divided in two categories: non manual (white collar/blue collar) and manual (semi-skilled, unskilled, housewives, and farm workers; Guerra, Alvarado, & Zunzunegui, 2008). Lifelong manual occupation was considered an adversity indicator in adult life.

Current adversity measures (i.e. at older ages)

These were determined by the assessment of current income sufficiency and social support. The self-reported question: "To what extent does your income allow you to meet your needs?" was used to assess participant *income sufficiency*

and the possible answers were very well, suitably, not very well, and not at all. Answers were recoded into very sufficient (very well), sufficient (suitably), and insufficient (not very well and not at all; Zunzunegui et al., 2015). Income sufficiency is a valid measure in the international context. Insufficient income is considered as an adversity measure (Litwin & Sapir, 2009).

Social support was measured according to different social ties using a scale developed and validated by members of the IMIAS team (Ahmed et al., 2018). This scale demonstrated satisfactory goodness of fit and consistent validity in the study population by factor analysis (Ahmed et al., 2018) The lack of support of friends, family members, children, and partner were considered to contribute to adversities in later life (Bélanger et al., 2016).

Sampling strategy

The study population was composed of community-dwelling men and women aged 65–74 years. At baseline, 2,002 subjects were recruited and 1,724 were followed until 2014. For these analyses, we only used data from those participants with valid measures in both 2012 and 2014.

Variables selection

This study used Fried's framework of frailty wich focuses solely on the physical attributes and Dannefer's cumulative advantage/disadvantage and life-course theory (Dannefer, 2003; Fried et al., 2001). Thus, we assume that social and economic adversities suffered in childhood or even in adult life might contribute to transition to a worse frailty status in older ages.The variables analyzed in this study were selected based on previous literature findings that links these variables to frailty or other health adverse outcomes known to be related to frailty in older adults (Bélanger et al., 2016; Phillips et al., 2016; Sousa, Guerra, Tu, & Patrı, 2014).

Statistical Analysis

Descriptive statistics were used to summarize frailty status in 2012 and 2014 by relative and absolute frequencies. They were also used to summarize the characteristics of those who were nonfrail in 2012, according to study covariates, as well as the characteristics of those who were "robust" and those who transitioned to a worse state (e.g., nonfrail to prefrail or nonfrail to frail) in the 2-year follow-up period.

Bivariate Poisson regression models with robust standard errors were performed to estimate the unadjusted relative risks of becoming prefrail or frail in 2 years. Multivariate Poisson regression analyses were performed to calculate the relative risks for the various adversity measures described above (i.e., education, childhood adversities, income, occupation, and social support variables) adjusting for age, sex, and study site. Relative risks are reported with their respective 95% confidence intervals (CIs) and p values. Statistical software R version 3.4.1 was used for all analyses and R library "GEE" was used to perform Poisson regression analyses.

Several articles in epidemiology suggested that when the outcome event is common (incidence or prevalence > 10%), it is more desirable to estimate the ratio of incidence or prevalence (RR/PR) because it is a direct estimate of the ratio of incidence/prevalence for two groups (Greenland, 2004; McNutt, Wu, Xue, & Hafner, 2003; Zou, 2004). The RR/PR can be estimated by log-binomial or Poisson regression model. Zou suggests using GEE Poisson model to estimate the RR/PR and confidence intervals because the GEE model (with robust error variances) result in a shorter confidence interval (Zou, 2004). The RR/PR is simply the exponentiated parameter estimates from the GEE model because poisson models use the log-link function. Similarly, RR/PR can be obtained by change the logit link function to log link function for binomial models.

Results

Among the 1,724 participants followed until 2014, 104 (6.0%) were classified as frail based on Fried's criteria in 2012; in 2014, 138 (8.0%) of participants were frail. Transitions to frailty status categories between the two assessment points are shown in Table 1. Accordingly, 366 (21.2%) participants migrated to a worse stage of frailty.

Table 2 describes the sample of those who were nonfrail in 2012 and depicts the predictors of incident worse frailty status in the 2-year follow-up. The mean age was 68.9 (SD = 2.8), more than a half of the sample reported high partner support (52.9%) and over one-third had insufficient incomes (35.6%). The unadjusted model shows that being older, female, living in Tirana or Natal, and reporting insufficient income were associated with greater risk of worse frailty status in 2014. Having worked in a nonmanual occupation and having high partner support appeared to protect against incident frailty. After statistical adjustment for participant age, sex, and study site, insufficient income (RR = 1.40; 95% CI = 1.00–1.96, p = .05) and high partner support (RR = 0.80; 95% CI = 0.64–1.01, p = .05) were marginally associated with worse frailty status risk. Across models, women (RR = 1.31; 95% CI = 1.09–1.57, p < .01) remained at increased risk of incident worse frailty status and those residing in Tirana (RR = 1.52; 95% CI = 1.13–2.04, p < .01) and Natal (RR = 1.82; 95% CI = 1.33–2.49, p < .01) had also greater risk.

Table 1. Transition Between Frailty Categories in 2 Years of Follow-up (n = 1,724)

		2014		
		Nonfrail	Prefrail	Frail
2012	Nonfrail	520 (63.7%)	278 (34.1%)	18 (2.2%)
	Prefrail	265 (33.0%)	469 (58.3%)	70 (8.7%)
	Frail	5 (4.8%)	49 (47.1%)	50 (48.1%)

Table 2. Poisson Regression Models Examining Social and Economic Predictors of the Relative Risks of Incident Frailty in 2014 Among Those Who Were Nonfrail in 2012

	Full sample	Worse frailty status	Robust	Unadjusted relative risk			Adjusted relative risk[a]		
	N = 804	294 (36.6%)	510 (63.4%)	RR	95% CI	*p*	RR	95% CI	*p*
Age									
Mean (*SD*)	68.9 (2.8)	69.2 (2.9)	68.7 (2.8)	1.04	(1.01–1.08)	<.01	1.04	(1.01–1.08)	<.01
Gender	***N* (%)**	***N* (%)**	***N* (%)**						
Male	415 (51.6%)	136 (32.8%)	279 (67.2%)						
Female	389 (48.4%)	158 (40.6%)	231 (59.4%)	1.24	(1.03–1.49)	.02	1.31	(1.09–1.57)	<.01
Research site									
Kingston	173 (21.5%)	49 (28.3%)	124 (71.7%)						
St. Hyacinthe	184 (22.9%)	61 (33.2%)	123 (66.8%)	1.17	(0.86–1.60)	.32	1.22	(0.90–1.67)	.20
Tirana	172 (21.4%)	72 (41.9%)	100 (58.1%)	1.48	(1.10–1.99)	<.01	1.52	(1.13–2.04)	<0.01
Manizales	181 (22.5%)	66 (36.5%)	115 (63.5%)	1.29	(0.95–1.75)	.104	1.31	(0.97–1.77)	0.07
Natal	94 (11.7%)	46 (48.9%)	48 (51.1%)	1.73	(1.26–2.37)	<.01	1.82	(1.33–2.49)	<0.01
Education									
Lowest	268 (33.3%)	98 (36.6%)	170 (63.4%)						
Middle	249 (31.0%)	104 (41.8%)	145 (58.2%)	1.14	(0.92–1.42)	0.22	1.14	(0.92–1.42)	0.22
Highest	287 (35.7%)	92 (32.1%)	195 (67.9%)	0.88	(0.70–1.10)	0.26	0.92	(0.73–1.15)	0.46
Occupation									
Manual work	433 (53.9%)	172 (39.7%)	261 (60.3%)						
Nonmanual work	371 (46.1%)	122 (32.9%)	249 (67.1%)	0.83	(0.69–1.00)	0.04	0.96	(0.77–1.18)	0.69
Income									
Very sufficient	223 (27.7%)	65 (29.1%)	158 (70.9%)						
Sufficient	295 (36.7%)	100 (33.9%)	195 (66.1%)	1.16	(0.90–1.51)	0.25	1.07	(0.80–1.43)	0.64
Insufficient	286 (35.6%)	129 (45.1%)	157 (54.9%)	1.55	(1.22–1.97)	<0.01	1.40	(1.00–1.96)	0.05
Childhood social adversity									
0–1 events	754 (93.8%)	273 (36.2%)	481 (63.8%)						
2–3 events	50 (6.2%)	21 (42.0%)	29 (58.0%)	1.16	(0.83–1.63)	0.39	1.16	(0.84–1.62)	0.36
Childhood economic adversity									
0–1 events	690 (85.8%)	245 (35.5%)	445(64.5%)						
2–3 events	114 (14.2%)	49 (43.0%)	65(57.0%)	1.21	(0.96–1.53)	0.11	1.07	(0.84–1.36)	0.56
Social support (friends)									
Has none	115 (14.3%)	47 (40.9%)	68 (59.1%)						
Low score (lowest quartile)	177 (22.0%)	62 (35.0%)	115 (65.0%)	0.86	(0.64–1.15)	0.31	1.02	(0.75–1.39)	0.89
High score (quartile 2, 3, 4)	512 (63.7%)	185 (36.1%)	327 (63.9%)	0.88	(0.69–1.13)	0.33	1.03	(0.78–1.35)	0.85
Social support (children)									
Has none	74 (9.2%)	29(39.2%)	45 (60.8%)						
Low score (lowest quartile)	182 (22.6%)	74(40.7%)	108 (59.3%)	1.04	(0.74–1.45)	0.82	1.00	(0.72–1.39)	0.99
High score (quartile 2, 3, 4)	548 (68.2%)	191 (34.9%)	357 (65.1%)	0.89	(0.65–1.21)	0.45	0.84	(0.62–1.14)	0.25
Social support (family)									
Has none	5 (0.6%)	2 (40.0%)	3 (60.0%)						
Low score (lowest quartile)	199 (24.8%)	76 (38.2%)	123 (61.8%)	0.95	(0.32–2.83)	0.93	0.71	(0.22–2.26)	0.55
High score (quartile 2, 3, 4)	600 (74.6%)	216 (36.0%)	384 (64.0%)	0.90	(0.31–2.65)	0.84	0.64	(0.20–2.02)	0.44
Social support (partner)									
Has none	240 (29.9%)	102 (42.5%)	138 (57.5%)						
Low score (lowest quartile)	139 (17.3%)	55 (39.6%)	84 (60.4%)	0.93	(0.72–1.20)	0.57	0.99	(0.76–1.29)	0.94
High score (quartile 2, 3, 4)	425 (52.9%)	137 (32.2%)	288 (67.8%)	0.76	(0.62–0.93)	<0.01	0.80	(0.64–1.01)	0.05

Note. Poisson regression models with robust standard errors were performed to estimate the unadjusted relative risks, as well as age, gender, and study site adjusted relative risks and their respective 95% confidence intervals (CIs).

[a]Adjusting for age, gender, and study sites.

Discussion, Implications, and Future Research

We observed that 21.2% of subjects in our sample transitioned to a worse category of frailty in 2 years. These results are relatively close to those observed in a longitudinal study that examined the transitions patterns of frailty syndrome in 200 community older adults over 65 years old in Brazil where 19.5% transitioned to a worse level of frailty (Lanziotti Azevedo da Silva et al., 2015). This reinforces the idea that the frailty concept can change over the time. Thus, health care interventions should focus on the pre frail group since they are on verge of becoming frail and present higher transitioning rates.

In our analyses, sociodemographic factors, such as older age, female sex, and having insufficient income at time of assessment, were related to a greater risk of incident worse status of frailty. These results are supported by a recent systematic review which evaluated risk and protective factors associated with incident or increased frailty among community-dwelling older adults in longitudinal studies and that highlighted positive associations between the above mentioned variables and frailty (Feng et al., 2017). Low income, especially, means that participants may not have enough money to pay bills, engage leisure activities, such as physical activity, buy medicine or even healthy food, which renders people more susceptible to frailty.

In this study, childhood adversities (i.e., social and economic) were not statistically independent associated with greater risk of transitioning to a worse status of frailty in 2 years. Opposite to our results, previous cross sectional studies from the IMIAS team have shown that early childhood adversities are linked to poor health status in old age indicated by isolated frailty components of the definition aplyed, such as low mobility (Guedes et al., 2016) and low physical performance measure (Sousa, Guerra, Tu, Patrı, et al., 2014) represented by gait speed and hand grip strength respectively. Nevertheless, in the composite of frailty, the association was not observed, maybe for the reason that childhood adversities were not strong enough, or perhaps they did not persist across the life course.

Although the physical phenotype of frailty is largely used, it is a composite of objective and subjective measures that can suffer from measurement errors and this may have influenced our results. Because measurement error can occur for each of the components that make up the outcome variable of frailty, it is possible that only the strongest predictors remain statistically significant in the multivariate models. Moreover, the short time between the two waves of assessments or the relatively small sample size, might also have influenced our results. These issues may explain why lifetime nonmanual occupation was a protective factor for incident frailty in the unadjusted model, but statistical significance was lost after adjustment.

Our results do not observe statistically significant associations between less general social support from friends, children, or family and incident worse frailty status. Similar situation was observed in a systematic review in which older people without strong social support or networks were not at increased risk for frailty or adverse health outcomes (Duppen et al., 2017). However, high partner support had a marginally statistically significant protective association against transitioning to worse frailty status, even after adjustment. For frail older people, it might be difficult to count on large social support as their social networks change and/or get smaller with age, thereby explaining the need for partner support. Marriage/common law relationships are probably the most common social context in which adults find a relationship that is vital to their psychological and social well-being, since a partner is the person from whom one is most likely to request aid and the person who provides nearly all kinds of aid (García-Faroldi, 2017); in other words, a partner is generally the person who shares a person's life in many aspects and can encourage the other to stay active, and other activities which may prevent frailty. Although this study did not observe a statistically significant association between other social support variables and frailty, is known that this topic is important to older adults' health. Nevertheless we need to take into account that the most frequent types of social support can vary across research site (Bélanger et al., 2016).

This study has several limitations, first our relatively small sample size does not allow us to perform robust analysis stratified by research site, this would help to understand the differences across the selected places. Second, the short period of time between baseline and follow-up, yet it is not possible to determine a reliable time to observe changes in frailty status, other longitudinal studies have considered longer periods between evaluation and follow-up as 5 (Fhon et al., 2018), 9, or 15 years (Stenholm et al., 2018), and third the relatively young age of our sample may underestimate the transitions among frailty status. On the other hand, the main strength of this study is that it examined incident frailty in different epidemiological contexts. In our results, we observed that older adults from Natal and Tirana are at higher risk of developing frailty and this observation reinforces the results of a previous publication of the IMIAS research group that observed that individuals from those sites have poorer health conditions generally (Doulougou et al., 2016). Furthermore, our study design allows us to establish a temporal sequence between our exposure measures and outcome; thus, it is possible to state that income insufficiency and social support from a partner contribute to frailty transitions and not the opposite (i.e., frailty influencing incomes or partner support).

To sum up, notably transitions among frailty status were observed even in a short range of time, mainly among the prefrail group indicating that it is important to develop and implement early prevention and intervention actions to older adults according to their age. Jadczak and colleagues highlights that exercise or combination of exercise and nutricional approach including protein supplementation as well fruit and dairy products can currently be recommended for prefrail and frail older adults and appeared to be bennefical to improve gait speed, muscular strength,

flexibility, resistance, balance and estimulate changes to less severe status of frailty (Jadczak, Makwana, Luscombe-Marsh, Visvanathan, & Schultz, 2018). These actions might stimulate changes to less severe stages of the physical phenotype of frailty, which could have substantial impact for public health.

Other than that, polices aiming to reduce social and economic disparities among the population are also welcome. However, to guide effective public health and social interventions (i.e., campaings to encourage young people and relatives to spend more time with their older family members and friends), it is necessary to continue investigating frailty from the perspective of the individuals who migrated from a worse category to a better one, as well as the possibility of the transition among older adults. Thus, we can better understand how social interventions targeting health and well-being of the older population could influence on frailty process to the worst or better.

Acknowledgments

This project was funded by the Canadian Institutes of Health Research, Institute of Aging, New Emerging Team; gender differences in immobility; reference number: AAM 108751. This study was also financed in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Conflict of Interest

None reported.

References

Ahmed, T., Belanger, E., Vafaei, A., Koné, G. K., Alvarado, B., Béland, F.,…Zunzunegui, M. V.; IMIAS Research Group. (2018). Validation of a social networks and support measurement tool for use in international aging research: The International Mobility in Aging Study. *Journal of Cross-Cultural Gerontology*, **33**, 101–120. doi:10.1007/s10823-018-9344-x

Alvarado, B. E., Zunzunegui, M.-V., Béland, F., & Bamvita, J.-M. (2008). Life course social and health conditions linked to frailty in Latin American older men and women. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, **63**, 1399–1406. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19126855

Barnes, L. L., Wilson, R. S., Everson-Rose, S. A., Hayward, M. D., Evans, D. A., & Mendes de Leon, C. F. (2012). Effects of early-life adversity on cognitive decline in older African Americans and whites. *Neurology*, **79**, 2321–2327. doi:10.1212/WNL.0b013e318278b607

Batistoni, S. S., Neri, A. L., & Cupertino, A. P. (2007). Validity of the center for epidemiological studies depression scale among Brazilian elderly. *Revista De Saude Publica*, **41**, 598–605. doi:10.1590/S0034-89102007000400014

Bélanger, E., Ahmed, T., Vafaei, A., Curcio, C. L., Phillips, S. P., & Zunzunegui, M. V. (2016). Sources of social support associated with health and quality of life: A cross-sectional study among Canadian and Latin American older adults. *BMJ Open*, **6**, e011503. doi:10.1136/bmjopen-2016-011503

Birnie, K., Martin, R. M., Gallacher, J., Bayer, A., Gunnell, D., Ebrahim, S., & Ben-Shlomo, Y. (2011). Socio-economic disadvantage from childhood to adulthood and locomotor function in old age: a lifecourse analysis of the Boyd Orr and Caerphilly prospective studies. *Journal of Epidemiology and Community Health*, **65**, 1014–1023. doi:10.1136/jech.2009.103648

Choi, J., Ahn, A., Kim, S., & Won, C. W. (2015). Global prevalence of physical frailty by Fried's criteria in community-dwelling elderly with national population-based surveys. *Journal of the American Medical Directors Association*, **16**, 548–550. doi:10.1016/j.jamda.2015.02.004

Clegg, A., Young, J., Iliffe, S., Rikkert, M. O., & Rockwood, K. (2013). Frailty in elderly people. *Lancet (London, England)*, **381**, 752–762. doi:10.1016/S0140-6736(12)62167-9

Collard, R. M., Boter, H., Schoevers, R. A., & Oude Voshaar, R. C. (2012). Prevalence of frailty in community-dwelling older persons: A systematic review. *Journal of the American Geriatrics Society*, **60**, 1487–1492. doi:10.1111/j.1532-5415.2012.04054.x

Dannefer, D. (2003). Cumulative advantage/disadvantage and the life course: Cross-fertilizing age and social science theory. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **58**, S327–S337. doi:10.1093/geronb/58.6.S327

Dos Santos Gomes, C., Pirkle, C. M., Zunzunegui, M. V., Taurino Guedes, D., Fernandes De Souza Barbosa, J., Hwang, P., & Oliveira Guerra, R. (2018). Frailty and life course violence: The International Mobility in Aging Study. *Archives of Gerontology and Geriatrics*, **76**, 26–33. doi:10.1016/j.archger.2018.02.002

Doulougou, B., Gomez, F., Alvarado, B., Guerra, R. O., Ylli, A., Guralnik, J., & Zunzunegui, M. V. (2016). Factors associated with hypertension prevalence, awareness, treatment and control among participants in the International Mobility in Aging Study (IMIAS). *Journal of Human Hypertension*, **30**, 112–119. doi:10.1038/jhh.2015.30

Duppen, D., Van der Elst, M. C. J., Dury, S., Lambotte, D., De Donder, L., &, D-SCOPE. (2017). The social environment's relationship with frailty: Evidence from existing studies. *Journal of Applied Gerontology*, 1, 1-24. doi:10.1177/0733464816688310

Eeles, E., & Low Choy, N. (2015). Frailty and mobility. *Interdisciplinary Topics in Gerontology and Geriatrics*, **41**, 107–120. doi:10.1159/000381200

Feng, Z., Lugtenberg, M., Franse, C., Fang, X., Hu, S., Jin, C., & Raat, H. (2017). Risk factors and protective factors associated with incident or increase of frailty among community-dwelling older adults: A systematic review of longitudinal studies. *PLoS One*, **12**, e0178383. doi:10.1371/journal.pone.0178383

Fhon, J. R. S., Rodrigues, R. A. P., Santos, J. L. F., Diniz, M. A., Santos, E. B. D., Almeida, V. C., & Giacomini, S. B. L. (2018). Factors associated with frailty in older adults: a longitudinal study. *Revista De Saude Publica*, **52**, 74. doi:10.11606/S1518-8787.2018052000497

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J.,…McBurnie, M. A. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, **56**, M146–M156. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11253156

García-Faroldi, L. (2017). The role of the partner in social support networks in Spain. *International Review of Sociology*, **27**, 334–352. doi:10.1080/03906701.2017.1298425

Gomez, F., Zunzunegui, M. V., Alvarado, B., Curcio, C. L., Pirkle, C. M., Guerra, R.,…Guralnik, J. (2018). Cohort profile: The International Mobility in Aging Study (IMIAS). *International Journal of Epidemiology*, **47**, 1393–1393h. doi:10.1093/ije/dyy074

Greenland, S. (2004). Model-based estimation of relative risks and other epidemiologic measures in studies of common outcomes and in case–control studies. *American Journal of Epidemiology*, **160**, 301–305. doi:10.1093/aje/kwh221

Guedes, D. T., Vafaei, A., Alvarado, B. E., Curcio, C. L., Guralnik, J. M., Zunzunegui, M. V., & Guerra, R. O. (2016). Experiences of violence across life course and its effects on mobility among participants in the International Mobility in Aging Study. *BMJ Open*, **6**, e012339. doi:10.1136/bmjopen-2016-012339

Guerra, R. O., Alvarado, B. E., & Zunzunegui, M. V. (2008). Life course, gender and ethnic inequalities in functional disability in a Brazilian urban elderly population. *Aging Clinical and Experimental Research*, **20**, 53–61.

Hoogendijk, E. O., Rijnhart, J. J. M., Kowal, P., Pérez-Zepeda, M. U., Cesari, M., Abizanda, P.,…Dent, E. (2018). Socioeconomic inequalities in frailty among older adults in six low- and middle-income countries: Results from the WHO study on global ageing and adult health (SAGE). *Maturitas*, **115**, 56–63. doi:10.1016/j.maturitas.2018.06.011

Hwang, P. W., dos Santos Gomes, C., Auais, M., Braun, K. L., Guralnik, J. M., & Pirkle, C. M. (2017). Economic adversity transitions from childhood to older adulthood are differentially associated with later-life physical performance measures in men and women in middle and high-income sites. *Journal of Aging and Health*, 1, 1–19. doi:10.1177/0898264317736846

Jadczak, A. D., Makwana, N., Luscombe-Marsh, N., Visvanathan, R., & Schultz, T. J. (2018). Effectiveness of exercise interventions on physical function in community-dwelling frail older people: An umbrella review of systematic reviews. *JBI Database of Systematic Reviews and Implementation Reports*, **16**, 752–775. doi:10.11124/JBISRIR-2017-003551

Kehler, D. S., Ferguson, T., Stammers, A. N., Bohm, C., Arora, R. C., Duhamel, T. A., & Tangri, N. (2017). Prevalence of frailty in Canadians 18–79 years old in the Canadian Health Measures Survey. *BMC Geriatrics*, **17**, 28. doi:10.1186/s12877-017-0423-6

Lanziotti Azevedo da Silva, S., Campos Cavalcanti Maciel, Á., de Sousa Máximo Pereira, L., Domingues Dias, J. M., Guimarães de Assis, M., & Corrêa Dias, R. (2015). Transition patterns of frailty syndrome in comunity-dwelling elderly individuals: A longitudinal study. *The Journal of Frailty & Aging*, **4**, 50–55. doi:10.14283/jfa.2015.43

Litwin, H., & Sapir, E. V. (2009). Perceived income adequacy among older adults in 12 countries: Findings from the survey of health, ageing, and retirement in Europe. *The Gerontologist*, **49**, 397–406. doi:10.1093/geront/gnp036

Marsh, A. P., Janssen, J. A., Ip, E. H., Barnard, R. T., Ambrosius, W. T., Brubaker, P. R.,…Rejeski, W. J. (2015). Assessing walking activity in older adults: Development and validation of a novel computer-animated assessment tool. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, **70**, 1555–1561. doi:10.1093/gerona/glv101

McNutt, L.-A., Wu, C., Xue, X., & Hafner, J. P. (2003). Estimating the relative risk in cohort studies and clinical trials of common outcomes. *American Journal of Epidemiology*, **157**, 940–943. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12746247

Phillips, S. P., Auais, M., Belanger, E., Alvarado, B., & Zunzunegui, M. V. (2016). Life-course social and economic circumstances, gender, and resilience in older adults: The longitudinal International Mobility in Aging Study (IMIAS). *SSM—Population Health*, **2**, 708–717. doi:10.1016/j.ssmph.2016.09.007

Pirkle, C. M., de Albuquerque Sousa, A. C., Alvarado, B., & Zunzunegui, M. V.; IMIAS Research Group. (2014). Early maternal age at first birth is associated with chronic diseases and poor physical performance in older age: Cross-sectional analysis from the International Mobility in Aging Study. *BMC Public Health*, **14**, 293. doi:10.1186/1471-2458-14-293

Schrama, P. P., Stenneberg, M. S., Lucas, C., & van Trijffel, E. (2014). Intraexaminer reliability of hand-held dynamometry in the upper extremity: A systematic review. *Archives of Physical Medicine and Rehabilitation*, **95**, 2444–2469. doi:10.1016/j.apmr.2014.05.019

Siriwardhana, D. D., Hardoon, S., Rait, G., Weerasinghe, M. C., & Walters, K. R. (2018). Prevalence of frailty and prefrailty among community-dwelling older adults in low-income and middle-income countries: A systematic review and meta-analysis. *BMJ Open*, **8**, e018195. doi:10.1136/bmjopen-2017-018195

Sousa, D. A., Guerra, R. O., Tu, M. T., & Patrı, A. C. (2014). Lifecourse adversity and physical performance across countries among men and women aged 65–74. *PLoS One*, **9**, 1–10. doi:10.1371/journal.pone.0102299

Sousa, D. A., Guerra, R. O., Tu, M. T., Patrı, A. C., Sousa, A. C. P. de A., Guerra, R. O.,…Zunzunegui, M.-V. (2014). Lifecourse adversity and physical performance across countries among men and women aged 65–74. *PLoS One*, **9**, e102299. doi:10.1371/journal.pone.0102299

de Souza Barbosa, J. F., Zepeda, M. U., Béland, F., Guralnik, J. M., Zunzunegui, M. V., & Guerra, R. O. (2016). Clinically relevant weakness in diverse populations of older adults participating in the International Mobility in Aging Study. *Age (Dordrecht, Netherlands)*, **38**, 25. doi:10.1007/s11357-016-9888-z

Stenholm, S., Ferrucci, L., Vahtera, J., Hoogendijk, E. O., Huisman, M., Pentti, J.,…Kivimäki, M. (2018). Natural course of frailty components in people who develop frailty syndrome: Evidence from two cohort studies. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 1, 1–8. doi:10.1093/gerona/gly132

Szanton, S. L., Seplaki, C. L., Thorpe, R. J., Jr., Allen, J. K., & Fried, L. P. (2010). Socioeconomic status is associated with frailty: The Women's Health and Aging Studies. *Journal of Epidemiology and Community Health*, **64**, 63–67. doi:10.1136/jech.2008.078428

Zou, G. (2004). A modified poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology*, **159**, 702–706. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15033648

Zunzunegui, M. V., Alvarado, B. E., Guerra, R., Gómez, J. F., Ylli, A., & Guralnik, J. M.; Imias Research Group. (2015). The mobility gap between older men and women: The embodiment of gender. *Archives of Gerontology and Geriatrics*, **61**, 140–148. doi:10.1016/j.archger.2015.06.005