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RESEARCH PAPER

Frailty and the impacts of the COVID-19 pandemic on community-living middle-aged and older adults: an analysis of data from the Canadian Longitudinal Study on Aging (CLSA)

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Abstract

Background: frailty imparts a higher risk for hospitalisation, mortality and morbidity due to COVID-19 infection, but the broader impacts of the pandemic and associated public health measures on community-living people with frailty are less known.
Methods: we used cross-sectional data from 23,974 Canadian Longitudinal Study on Aging participants who completed a COVID-19 interview (Sept–Dec 2020). Participants were included regardless of whether they had COVID-19 or not. They were asked about health, resource, relationship and health care access impacts experienced during the pandemic. Unadjusted and adjusted prevalence of impacts was estimated by frailty index quartile. We further examined if the relationship with frailty was modified by sex, age or household income.
Results: community-living adults (50–90 years) with greater pre-pandemic frailty reported more negative impacts during the first year of the pandemic. The frailty gradient was not explained by socio-demographic or health behaviour factors. The largest absolute difference in adjusted prevalence between the most and least frail quartiles was 15.1% (challenges accessing healthcare), 13.3% (being ill) and 7.4% (increased verbal/physical conflict). The association between frailty and healthcare access differed by age where the youngest age group tended to experience the most challenges, especially for those categorised as most frail.
Conclusion: although frailty has been endorsed as a tool to inform estimates of COVID-19 risk, our data suggest it may have a broader role in primary care and public health by identifying people who may benefit from interventions to reduce health and social impacts of COVID-19 and future pandemics.

Keywords: Canadian Longitudinal Study on Aging (CLSA), COVID-19, pandemic, frailty, health care utilisation, older people

Key Points

- Community-living adults living with higher levels of frailty experienced more negative COVID-related health, social and healthcare access impacts during the first year of the pandemic than those with lower levels of frailty
- The gradients between pandemic impacts across frailty level were not explained by other socio-demographic or health behaviour factors
- For some impacts the pattern across frailty level differed by age, sex, and income level
- The pattern was most consistent for healthcare access impacts across age groups
- Younger participants with higher frailty levels were more likely to be impacted negatively

Introduction

During the COVID-19 pandemic, older adults experienced increased risk of hospitalisation and death [1–4], but the complete scope of impacts of the pandemic is not yet understood. Public health measures implemented to decrease virus transmission also had unintended negative physical and mental health consequences [5].

Because older adults disproportionately experienced severe disease and death during the pandemic, age-based measures to reduce risk were frequently implemented [6], but chronological age alone does not fully account for the heterogeneity in vulnerability between age groups [7]. Frailty, a multidimensional syndrome associated with increased vulnerability to stressors, predicts multiple adverse outcomes in community-living [8] and inpatient populations [9]. It is a stronger predictor than age of healthcare utilisation [10] and receiving informal care [11]. Although some studies have used a 'frailty lens' to examine health impacts of COVID-19, most have focussed on the direct impact of COVID-19 on mortality in hospitalised patients [12–15] or long-term care residents [16, 17].

Frail older individuals with less reserve to respond to external stressors are more susceptible to developing psychological distress and social isolation [18], which increased with COVID-19-related restrictions [6, 19, 20]. Although people living with frailty may have had the greatest healthcare needs during the pandemic, they also experienced challenges accessing both in-person and virtual healthcare [21–23], which likely increased demands on informal caregivers. During the first COVID-19 wave, home care visits decreased [24] and informal care provision grew [25]. Although caregiving has many positive aspects, the increase in demand coupled with difficulties in accessing needed healthcare led to greater caregiver stress, depression and a lower sense of well-being that sometimes strained relationships with care-recipients [26].

Studying a large population-based sample of older adults categorised by their frailty level may help identify subgroups more vulnerable to the noted health and social impacts of the COVID-19 pandemic. We analysed data from a COVID-19 questionnaire administered to participants in an existing population-based longitudinal study to examine whether pre-pandemic frailty was associated with health, resource, relationship and/or healthcare access impacts experienced during the COVID-19 pandemic. We hypothesised that participants with higher frailty levels would more often report impacts. In previous work, we demonstrated that frailty is related to age, sex and income [27]. We also explored whether the impact of frailty level was modified by these factors.

Methods

Study design/setting

The Canadian Longitudinal Study on Aging (CLSA) is a comprehensive research platform collecting data on health and ageing [28]. Baseline data were obtained on 51,338 participants in 2011–2015. Participants are seen in 3-year cycles for up to 20 years. The first follow-up (FUP1) was completed on 48,893 participants (95% retention) in 2015–2018. In response to the COVID-19 pandemic, a questionnaire-based addition to the main study was launched on 15 April 2020. These COVID-19 questionnaires were administered at weekly to monthly intervals via phone or web with the final contact (referred to as the COVID-19 Exit survey) taking place between 29 September–29 December 2020 (https://www.clsa-elcv.ca/researchers/clsa-covid-19-studies/covid-19-questionnaire-study). The COVID-19 study was approved by the research ethics boards (REBs) of participating institutions. Data from the CLSA baseline, FUP1 and COVID-19 questionnaires were used.

Participants

CLSA participants were community-living adults aged 45–85 years at enrolment. People residing in institutions, full-time armed forces members, those living on First Nations reserves or in a Canadian Territory, unable to respond in English or French or not able to provide informed consent were ineligible. Of the 51,338 participants, 21,241 were randomly selected from the 10 Canadian provinces and provided information through telephone interviews (tracking cohort). The other 30,097 participants (comprehensive cohort) lived within 25–50 km of one of 11 Data Collection

Sites (DCSs) located across Canada and underwent both in-home interviews and local DCS visits where additional data were collected.

Of 51,338 initially enrolled participants, 42,511 were still active in the CLSA at the launch of the CLSA COVID-19 study, 28,559 (67.2%) agreed to participate and of them 24,114 (84.4%) completed the COVID-19 Exit survey. In total, 23,974 (99.4%) of this group also completed their FUP1 assessment. This group included 121 (0.51%) participants reporting a positive COVID-19 test or being told they had COVID-19 by a healthcare professional (defined as probable COVID-19 infection). Given our primary interest was assessing the impact of frailty on living through the initial days of the pandemic and accompanying public health response irrespective of infection status, both COVID-19 positive and negative participants were included in our primary analyses. In sensitivity analyses, we examined COVID-19 as a covariate (see Results and Appendix 3b). Compared with the CLSA cohort at FUP1, those completing the COVID-19 Exit survey were less likely to have a household income <$50,000 and more likely to live in a rural setting and be a non-drinker (Appendix 1).

Variables

Frailty index

A frailty index (FI) was constructed using standard criteria from a range of health deficits assessed at FUP1 [29, 30]. Deficits were recoded as '0' if absent and '1' if present. For non-binary variables, a gradient from 0 to 1 was created using equal steps. Each participant's FI value was the sum of deficits present divided by the total number of deficits considered. Since the deficits differed slightly for tracking and comprehensive participants, we calculated cohort-specific FI quartiles (FIQs) to harmonise the cohorts with 1 representing participants with the lowest FI scores (i.e. least frail) and 4 with the highest FI scores (i.e. most frail). This allowed us to examine gradients in prevalence of COVID-19-related impacts by frailty severity. Descriptive statistics for 85 deficits comprising the FI for tracking and 76 for comprehensive participants (71 in common) are presented in Appendix 2a and 2b.

COVID-19 impacts

At the COVID-19 Exit survey, participants were asked if they experienced any of several potential impacts during the pandemic. For this paper, we examined *health impacts* (participant was ill, someone close was ill, someone close died), *resource impacts* (loss of income and unable to access necessary food/supplies) and *relationship impacts* (separation from family, increased conflict, breakdown in family relationships). Participants were further asked if they had experienced any challenges accessing healthcare during the pandemic. If yes, they were asked if these *healthcare access impacts* were for: primary care, specialist care, prescription medications, pharmacist, diagnostic testing, screening tests or a delay in surgery. Finally, to better understand barriers to healthcare access, participants were asked if they were unable to use videoconferencing technologies or had no access to a computer.

Covariates

We examined if impact by FIQ differed by participant sex (female vs. male), age at COVID-19 Exit survey (<55, 55–64, 65–74 and ≥ 75 years) and pre-pandemic annual household income in Canadian Dollars (CDN) (<$20,000, $20,000–$49,999, $50,000–$99,999, $100,000–$149,000, and ≥ $150,000). Pre-pandemic covariates used for adjustment were chosen based on the frailty literature [31, 32] and included: marital status (married/common-law or other), smoking status (current/former daily smoker or other), nutritional risk (score < 32 on AB SCREEN™ II Nutritional Risk [33]), social participation restriction due to health limitations, living alone and low physical activity (<75 min/week of vigorous or 150 min/week of moderate intensity physical activity) [34].

Statistical analysis

The association between FIQ with each COVID-19 impact was estimated using logistic regression. Unadjusted models included FIQ alone and adjusted models included FIQ and all covariates. Predicted prevalence with 95% confidence intervals (CIs) was estimated for each COVID-19 impact by FIQ using the unadjusted and adjusted logistic regression models. We also examined the gradients of these prevalence estimates across FIQ (i.e. the change in prevalence for each frailty quartile compared with the first (least frail) quartile). Finally, interaction effects were used in the logistic regression model to examine if the gradients of FIQ differed by (i) age, (ii) sex or (iii) pre-pandemic household income. As the models can be unstable when outcome prevalence is low, interaction analysis was done only when the impact prevalence was at least 1% in one of the FIQs. To interpret statistically significant interactions, we plotted the predicted impact prevalence across FIQ for each age, sex or income subgroup. As a sensitivity analysis, the final interaction models (other than for being personally ill or having a person close to them being ill) were re-run including COVID-19 status as a covariate.

Although the amount of missing covariate data was relatively low (<7.3% for all variables), we speculated that frailer participants might have more missing data. Furthermore, due to administrative reasons, a subset of cognitive tests was not conducted in the comprehensive cohort during the first months of FUP1. Multiple imputation was conducted using predictive mean matching to provide estimates less prone to bias [35]. We investigated the number of burn-in iterations for stability of the imputed data and used 40 iterations for the imputed data sets. We further implemented 10 imputed data sets and evaluated the efficiency of the imputations. We

Table 1. Socio-demographic, health behaviour and healthcare utilisation data for 23,974 CLSA participants completing follow-up 1 and the COVID-19 Exit survey, overall and by frailty quartile

Characteristic	Frailty Q1 (*n* = 5,939)	Frailty Q2 (*n* = 6,009)	Frailty Q3 (*n* = 6,014)	Frailty Q4 (*n* = 6,012)	Overall (*n* = 23,974)
Sex					
Males	3,210 (54.31%)	3,004 (49.83%)	2,790 (46.38%)	2,226 (36.98%)	11,230 (46.84%)
Females	2,701 (45.69%)	3,025 (50.17%)	3,225 (53.62%)	3,793 (63.02%)	12,744 (53.16%)
Age group					
<55	403 (6.82%)	302 (5.01%)	207 (3.44%)	185 (3.07%)	1,097 (4.58%)
55–64	2,381 (40.28%)	1,958 (32.48%)	1,612 (26.80%)	1,300 (21.60%)	7,251 (30.25%)
65–74	2,207 (37.34%)	2,274 (37.72%)	2,224 (36.97%)	2,055 (34.14%)	8,760 (36.54%)
75+	920 (15.56%)	1,495 (24.80%)	1,972 (32.78%)	2,479 (41.19%)	6,866 (28.64%)
Total household income					
< $20,000	58 (0.98%)	127 (2.11%)	194 (3.23%)	582 (9.67%)	961 (4.01%)
$20,000–$49,999	684 (11.57%)	1,018 (16.89%)	1,467 (24.39%)	2,116 (35.16%)	5,285 (22.04%)
$50,000–$99,999	2,059 (34.83%)	2,397 (39.76%)	2,453 (40.78%)	2,147 (35.67%)	9,056 (37.77%)
$100,000–$149,999	1,581 (26.75%)	1,316 (21.83%)	1,115 (18.54%)	768 (12.76%)	4,780 (19.94%)
$150,000 +	1,529 (25.87%)	1,171 (19.42%)	786 (13.07%)	406 (6.75%)	3,892 (16.23%)
Marital status					
Married/Common-law	4,852 (82.08%)	4,549 (75.45%)	4,093 (68.05%)	3,345 (55.57%)	16,839 (70.20%)
Other	1,059 (17.92%)	1,480 (24.55%)	1,922 (31.95%)	2,674 (44.43%)	7,135 (29.80%)
Living alone					
Yes	782 (13.23)	1,147 (19.02%)	1,549 (25.75%)	2,130 (35.39%)	5,608 (23.39%)
No	5,129 (86.77%)	4,882 (80.98%)	4,466 (74.25%)	3,889 (64.61%)	18,366 (76.61%)
Smoking status					
Current/former daily smoker	3,691 (62.44%)	4,067 (67.46%)	4,194 (69.73%)	4,322 (71.81%)	16,274 (67.88%)
Other	2,220 (37.56%)	1,962 (32.54%)	1,821 (30.27%)	1,697 (28.19%)	7,700 (32.12%)
Nutritional risk					
High risk	244 (4.13%)	459 (7.61%)	779 (12.95%)	1,667 (27.70%)	3,149 (13.14%)
Low risk	5,667 (95.87%)	5,570 (92.39%)	5,236 (87.05%)	4,352 (72.30%)	20,825 (86.86%)
Social participation					
Restricted by health	53 (0.90%)	141 (2.34%)	299 (4.97%)	1,113 (18.49%)	1,606 (6.70%)
Not restricted by health	5,858 (99.10%)	5,888 (97.66%)	5,716 (95.03%)	4,906 (81.51%)	22,368 (93.30%)
Low physical activity					
Yes	2,641 (44.68%)	2,181 (36.18%)	1,671 (27.78%)	1,064 (17.68%)	7,557 (31.52%)
No	3,270 (55.32%)	3,848 (63.82%)	4,344 (72.22%)	4,955 (82.32%)	16,417 (68.48%)

used Rubin's rule for pooling the parameters of the logistic regression models. The method for combining *P*-values of the significance of factors (frailty quartiles, age, sex, income and their interactions) was adapted from Fisher's approach [36]. We chose this method because it is conservative when Chi-square statistics are positively correlated [36]. All analyses were conducted using SAS version 9.4 [37] and R version 4.1.0 [38]. We used the Strengthening the Reporting of Observational Studies in Epidemiology checklist when drafting this manuscript [39].

Results

Participants

Table 1 displays the characteristics of the 23,974 FUP1 and COVID-19 Exit survey respondents overall and by FI quartile. The sample included 53.2% females, 65.2% aged 65+ years and 26.1% with a household income <$50,000. The proportions female, 65+ years of age, lower income, non-married status and living alone increased with frailty level.

Pandemic impacts and frailty quartiles

Table 2 presents unadjusted and adjusted prevalence estimates by FIQ and gradients (change in prevalence for quartiles 2–4 compared with quartile 1 (least frail)) for COVID-19 health, resource and relationship impacts. Other than loss of income (unadjusted), there was an increasing prevalence gradient for all COVID-19 impacts with participants at higher frailty levels more often reporting impacts. The most commonly reported adverse impact was family separation, which was reported by over 50% of participants. The largest absolute difference between prevalence in FIQ4 (most frail) and FIQ1 (least frail) in adjusted analyses was 13.3% for being ill, 7.4% for increased verbal or physical conflict and 7% for being unable to access necessary supplies.

Increasing FIQ was associated with increased healthcare access challenges (Table 3). The largest gradients between FIQs were found for the overall measure of any healthcare access challenge (32.8% of participants in FIQ4 reported a challenge accessing healthcare versus 17.7% in FIQ1).

Table 2. Estimated unadjusted and adjusted prevalence of health, resource and relationship impacts experienced during the COVID-19 pandemic data for 23,974 CLSA participants completing follow-up 1 and the COVID-19 Exit survey by frailty quartile

COVID-19 impact	FIQ	Unadjusted		Adjusted[a]	
		Prevalence	FI Gradient	Prevalence	FI Gradient
Health impacts					
You were ill	Q1	7.7 (7.1, 8.5)	–	9.8 (8.6, 11.1)	–
	Q2	9.5 (8.8, 10.4)	1.8	12.3 (10.9, 13.9)	2.5
	Q3	12.6 (11.8, 13.5)	4.9	16.4 (14.8, 18.2)	6.6
	Q4	19.0 (18, 20)	11.2	23.1 (21.3, 25)	13.3
People close to you were ill	Q1	12.4 (11.6, 13.3)	–	12 (10.7, 13.5)	–
	Q2	13.2 (12.4, 14.1)	0.8	13.3 (11.9, 14.8)	1.3
	Q3	15.3 (14.3, 16.2)	2.8	16 (14.4, 17.7)	4
	Q4	17.0 (16.1, 18)	4.6	18.2 (16.7, 19.9)	6.2
Death of a person close to you	Q1	12.7 (11.9, 13.6)	–	14.2 (12.6, 15.8)	–
	Q2	15.2 (14.3, 16.2)	2.5	16.5 (14.8, 18.2)	2.3
	Q3	15.8 (14.9, 16.8)	3.1	16.7 (15.1, 18.5)	2.6
	Q4	18.0 (17.0, 19.0)	5.3	18.1 (16.6, 19.7)	3.9
Resource impacts					
Loss of income	Q1	12.4 (11.5, 13.2)	–	10.5 (9.2, 11.9)	–
	Q2	12.0 (11.1, 12.8)	−0.4	11.5 (10.1, 13.0)	1
	Q3	11.3 (10.5, 12.1)	−1.1	12.1 (10.7, 13.7)	1.6
	Q4	12.3 (11.5, 13.2)	0	14.7 (13.2, 16.3)	4.2
Unable to access necessary supplies	Q1	3.2 (2.8, 3.7)	–	3.6 (2.9, 4.4)	–
	Q2	4.7 (4.2, 5.3)	1.5	5.7 (4.8, 6.8)	2.1
	Q3	5.8 (5.2, 6.5)	2.6	7.7 (6.5, 9.0)	4.1
	Q4	7.9 (7.3, 8.7)	4.7	10.6 (9.3, 12)	7
Relationship impacts					
Family separation	Q1	49.6 (48.3, 50.9)	–	47.7 (45.3, 50.1)	–
	Q2	51.0 (49.7, 52.3)	1.4	50.1 (47.8, 52.5)	2.5
	Q3	50.6 (49.3, 52)	1.1	50.8 (48.5, 53.1)	3.1
	Q4	51.8 (50.5, 53)	2.2	52.7 (50.7, 54.7)	5
Increase verbal or physical conflict	Q1	3.7 (3.2, 4.2)	–	3.7 (3.0, 4.5)	–
	Q2	4.1 (3.6, 4.7)	0.4	4.4 (3.7, 5.4)	0.8
	Q3	6.2 (5.6, 6.9)	2.5	7.2 (6.1, 8.5)	3.5
	Q4	9.2 (8.5, 10)	5.5	11.0 (9.7, 12.5)	7.4
Breakdown of family relationships	Q1	2.8 (2.4, 3.2)	–	3.1 (2.5, 3.8)	–
	Q2	3.7 (3.2, 4.2)	0.9	4.4 (3.6, 5.4)	1.3
	Q3	4.9 (4.3, 5.4)	2.1	6.1 (5.1, 7.3)	3
	Q4	7.0 (6.4, 7.7)	4.2	8.7 (7.5, 10.1)	5.7

FI gradient is the change in prevalence for each FI quartile compared with the first quartile [a]Adjusted for age, sex, income, marital status, living alone, social participation, smoking status, physical activity and nutritional risk

The gradients between FIQs generally became larger after adjustment for confounders. Accessing primary and specialist care was the most reported challenges. Less than 1% reported challenges accessing a pharmacist. Challenges accessing diagnostic tests were more common than screening tests. Less than 2% in any FIQ group reported difficulty accessing healthcare due to videoconferencing challenges.

Influence of age, sex and income

Interaction analyses were conducted for all impacts except access to a pharmacist because of its low prevalence (Appendix 3a). Statistically significant interactions are presented in Figures 1–3.

For age, there was a statistically significant interaction for one health impact (you were ill), one relationship impact (increased verbal or physical conflict) and for all healthcare access impacts except prescription medications (Figure 1). Other than surgical delays and barriers using videoconferencing technologies, the oldest age group generally had the lowest overall prevalence of impacts and the smallest increases in prevalence across FIQs. The youngest age group experienced the highest prevalence of most impacts, especially for those most frail (FIQ4). This was especially evident for challenges accessing specialist care and diagnostic testing.

There were significant interactions between FIQs and sex for resource impacts, loss of income and four of the eight healthcare access impacts (Figure 2). Loss of income

Table 3. Estimated unadjusted and adjusted prevalence of challenges accessing healthcare experienced during the COVID-19 pandemic data for 23,974 CLSA participants completing follow-up 1 and the COVID-19 Exit survey by frailty quartile

Healthcare challenge	Frailty quartile	Unadjusted		Adjusted[a]	
		Prevalence	FI Gradient	Prevalence	FI Gradient
Any challenges	Q1	17.7 (16.7, 18.7)	–	18.2 (16.6, 19.9)	–
	Q2	23.4 (22.4, 24.6)	5.8	25.5 (23.6, 27.6)	7.3
	Q3	28.6 (27.5, 29.8)	11	32.5 (30.3, 34.7)	14.3
	Q4	32.8 (31.6, 34.1)	15.2	38.1 (36.1, 40.2)	19.9
Primary care	Q1	11.6 (10.8, 12.5)	–	11.6 (10.4, 13.1)	–
	Q2	15.8 (14.9, 16.8)	4.2	16.8 (15.2, 18.5)	5.2
	Q3	18.9 (17.9, 19.9)	7.3	21.1 (19.2, 23)	9.4
	Q4	22.4 (21.4, 23.5)	10.8	25.9 (24, 27.8)	14.2
Specialist care	Q1	5.7 (5.1, 6.3)	–	6.1 (5.2, 7.1)	–
	Q2	8.1 (7.4, 8.9)	2.4	9.3 (8.1, 10.7)	3.2
	Q3	10.9 (10.1, 11.7)	5.2	13.2 (11.7, 14.9)	7.2
	Q4	14.1 (13.2, 15)	8.4	17.7 (16.1, 19.5)	11.7
Prescription medications	Q1	1.1 (0.8, 1.4)	–	0.83 (0.58, 1.2)	–
	Q2	2 (1.7, 2.4)	1	1.8 (1.3, 2.4)	1
	Q3	2.7 (2.3, 3.1)	1.6	2.6 (2, 3.4)	1.8
	Q4	3.9 (3.5, 4.5)	2.9	4.3 (3.4, 5.3)	3.5
Pharmacist	Q1	0.19 (0.1, 0.36)	–	0.15 (0.06, 0.35)	–
	Q2	0.32 (0.2, 0.51)	0.13	0.27 (0.13, 0.56)	0.12
	Q3	0.37 (0.24, 0.58)	0.18	0.33 (0.16, 0.67)	0.18
	Q4	0.67 (0.49, 0.92)	0.48	0.65 (0.37, 1.14)	0.5
Diagnostic tests	Q1	4.2 (3.7, 4.7)	–	4.7 (3.9, 5.6)	–
	Q2	6.7 (6.1, 7.5)	2.6	8.2 (7, 9.5)	3.5
	Q3	8.7 (8, 9.5)	4.5	11.1 (9.6, 12.7)	6.4
	Q4	11 (10.2, 11.8)	6.8	14 (12.5, 15.6)	9.2
Screening tests	Q1	2 (1.6, 2.4)	–	1.9 (1.5, 2.5)	–
	Q2	2.8 (2.4, 3.2)	0.81	2.9 (2.3, 3.7)	0.97
	Q3	3.6 (3.2, 4.1)	1.6	4 (3.2, 4.9)	2.1
	Q4	5 (4.5, 5.6)	3	5.5 (4.6, 6.6)	3.6
Surgery delay	Q1	1.1 (0.81, 1.4)	–	1.05 (0.74, 1.5)	–
	Q2	1.6 (1.3, 2)	0.6	1.7 (1.2, 2.3)	0.64
	Q3	2.4 (2, 2.8)	1.3	2.5 (1.9, 3.3)	1.5
	Q4	3.4 (2.9, 3.9)	2.3	3.7 (2.9, 4.6)	2.6
Unable to zoom	Q1	0.23 (0.13, 0.39)	–	0.36 (0.19, 0.7)	–
	Q2	0.49 (0.33, 0.72)	0.3	0.73 (0.43, 1.24)	0.4
	Q3	0.92 (0.7, 1.2)	0.7	1.24 (0.8, 1.9)	0.9
	Q4	1.9 (1.6, 2.3)	1.7	2 (1.4, 2.9)	1.6

FI gradient is the change in prevalence for each FI quartile compared with the first quartile [a]In addition to age, sex, and income all models are adjusted for marital status, living alone, social participation, smoking status, physical activity and nutritional risk

was similar between sexes in FIQ1 but was experienced more often by males than females in FIQ2–4. For specialist care, prescription medications and surgery delay, the access challenges were similar for FIQ1–FIQ3 and higher for males than females in FIQ4. As for diagnostic testing, males had more access challenges in FIQ1, whereas females had more in FIQ4. The difference in estimated prevalence between males and females for all in healthcare access impacts was 2% or less.

There was no statistical evidence that the effect of FIQ on health impacts or healthcare access differed by income category. There were for resource impacts (loss of income and unable to access supplies) and all three relationship impacts (Figure 3). Although there was no clear pattern with respect to income, the lowest income group seemed to deviate from the other income groups, especially for lowest FIQ.

Including COVID-19 status as a covariate had no substantive impact on the results except for the sex by frailty quartile interaction for access to screening, which became statistically significant with a larger gradient over FIQ for females compared with males (Appendix 3b).

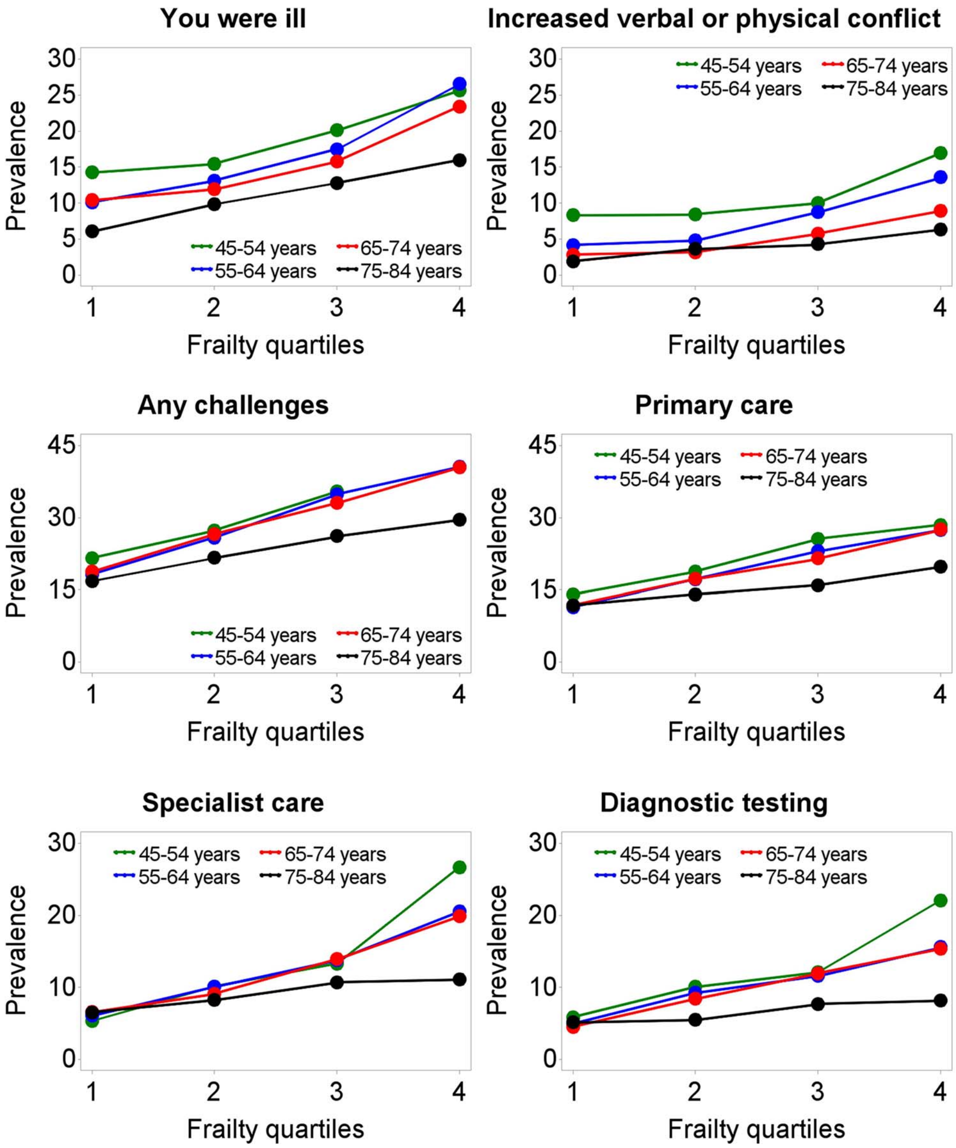

Figure 1. Estimated adjusted prevalence of health, resource, relationship and healthcare access impacts experienced during the COVID-19 pandemic for logistic regression models with a statistically significant interaction between FIQ and age group (<55: green, 55–64: blue, 65–74: red and ≥ 75 years: black). Interaction models are adjusted for sex, income, marital status, living alone, social participation, smoking status, physical activity and nutritional risk.

Discussion

Community-living adults with higher levels of pre-pandemic frailty reported not only more negative health impacts, but also resource, relationship and healthcare access challenges during the first year of the COVID-19 pandemic in Canada. The gradient across frailty levels was not explained by socio-demographic or health behaviour factors and generally increased after covariate adjustment. The association between FIQ and some COVID-19 pandemic impacts differed among subgroups. Most strikingly, the association of FIQ with healthcare access impacts differed across age groups. These data suggest relatively younger participants with higher frailty levels were more likely to be impacted negatively.

After family separation, the most commonly reported pandemic-related impacts were health (being ill, or someone close being ill or dying) and resources (loss of income). Although others have reported increased health-related impacts in frail adults with COVID-19 [12, 40], none have examined loss of income related to frailty. The frailty gradient for loss of income appeared only in adjusted analyses, which may be explained by the strong association between frailty and age and the inverse relationship between age and income loss during the pandemic [41]. The breakdown in family relations showed a 5.7% absolute and 185% relative increase

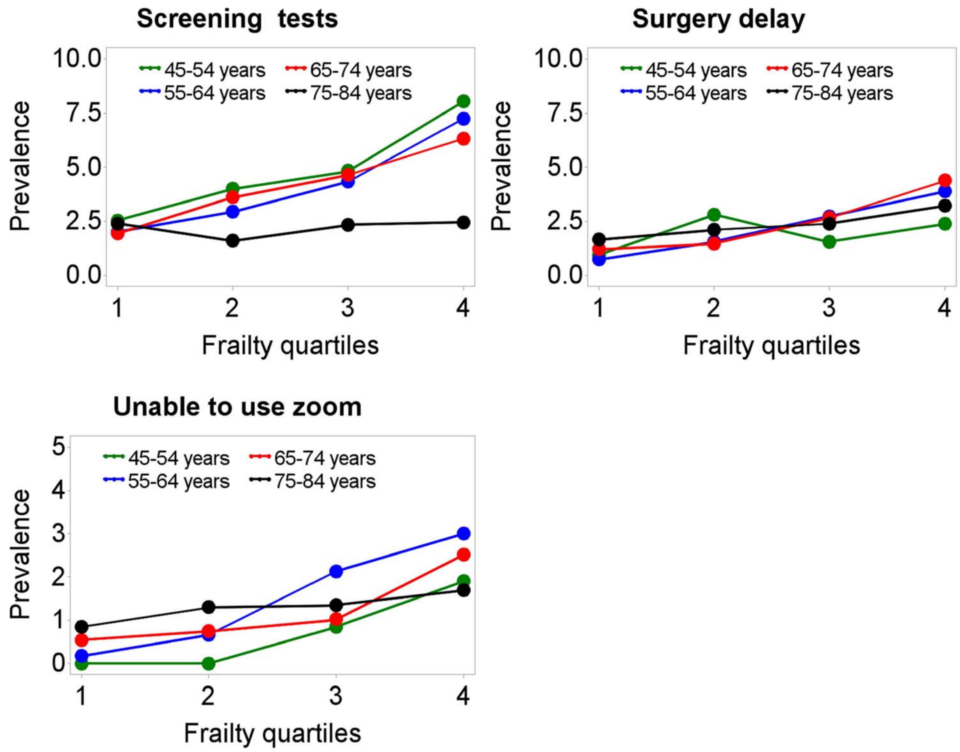

Figure 1. Continued.

in FIQ4 compared with FIQ1 after adjusting for all other covariates. Possibly this was related to reduced formal home care support during the pandemic increasing the burden on family carers [24–26].

The prevalence of most impacts was lowest for the oldest age group and highest in the youngest with the differences in prevalence across age groups increasing with greater frailty severity. This was especially true for specialist visits and diagnostic tests where the difference in adjusted prevalence between the youngest and oldest age group was negligible for FIQ1 and 15.6 and 13.9%, respectively, higher in FIQ4. Younger participants with higher frailty levels appeared more likely to be impacted by the pandemic, but the underlying reasons for this are unknown. Lower healthcare access challenges in the oldest subgroup may also reflect the low prevalence of participants reporting challenges accessing videoconferencing (2% or less in all FIQs) and the increased use of telehealth for routine care. In the US, telehealth visits increase by 154% from March 2019 to March 2020 [42]. In Ontario, virtual care increased from 1.6% of all ambulatory visits in the second quarter of 2019 to 70.6% in the same period in 2020 [43]. Although there are known sex differences in frailty [44] and healthcare utilisation patterns [45], we did not find that the effect of FIQ on healthcare access differed greatly by sex. Moreover, there were no statistically significant interactions with pre-pandemic household income. This is consistent with a study that found very few European countries showing significant income-related inequalities associated with unmet healthcare needs [46].

Older participants reported a lower prevalence of being ill with a less steep gradient across FIQs than the other age groups. This may reflect greater adherence to public health recommendations and cocooning (retreating from public life) found in older adults [6]. However, loss of income was similar between males and females in FIQ1, males with higher levels of frailty reported this more often than females. However, there was no consistent pattern for interactions between pre-pandemic household income and resource impacts, although the lowest income group showed differences from other income groups. This could reflect a larger impact from the loss of paid carers in these groups [25, 26]. More research would be needed to understand these interactions.

Strengths and Limitations

Using an existing national population-based cohort, we examined the health and social impacts of the COVID-19 pandemic on middle-aged and older adults with differing degrees of frailty. The large sample size allowed investigating how the impact of frailty level differed across subgroups based on age, sex and income. This reinforced that not all subgroups of the population experienced pandemic impacts equally.

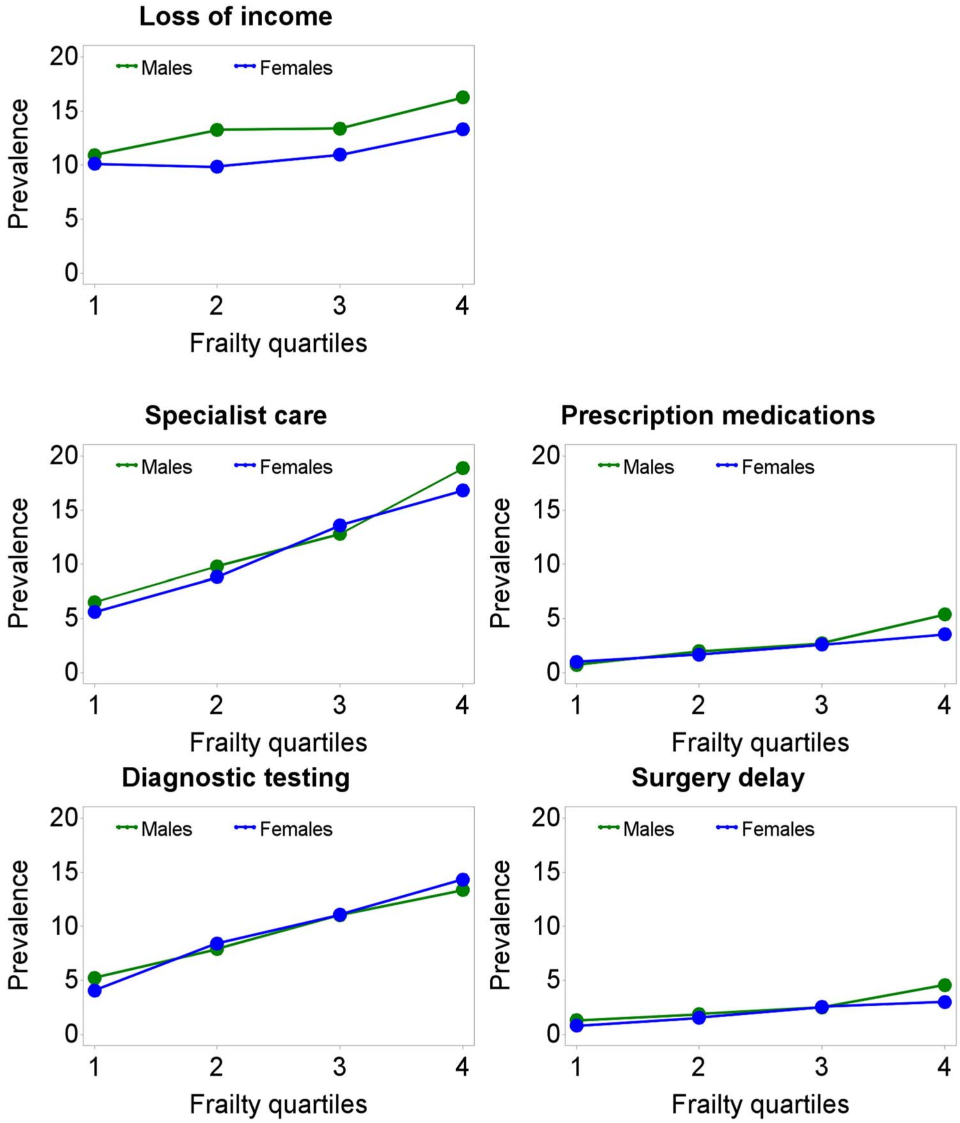

Figure 2. Estimated adjusted prevalence of health, resource, relationship and healthcare access impacts experienced during the COVID-19 pandemic for logistic regression models with a statistically significant interaction between FIQ and sex (males: green, female: blue). Interaction models are adjusted for age, income, marital status, living alone, social participation, smoking status, physical activity and nutritional risk.

A limitation of the CLSA is that participants are largely white, well-educated and economically advantaged. Furthermore, the response rate of the COVID-19 Exit survey was 56.4%. Participants with lower income were less likely to participate in the study, limiting generalisability to more economically marginalised populations. Our results may also be sensitive to the deficits and cut-points utilised in the FIs. However, we constructed the index using a standard approach [30], validated it in a separate publication, and have used it to explore the social underpinnings of frailty in another study [27, 47]. We chose to use quartiles instead of a single cut-point so we could examine gradients across a range of frailty severity. Finally, we chose a conservative method to estimate *P*-values across the imputed datasets and may have underrepresented significant interaction effects.

Clinical and public health implications

Understanding the health-related impacts of both the COVID-19 pandemic and the public health response on older people have been identified as research priorities [48]. Additional enquiry is needed to elucidate how measuring frailty can inform prevention and care [49]. We found frailty gradients not only for health but also resource, relationship and healthcare access impacts during the pandemic. Younger old rather than mid to older old reported the greatest access

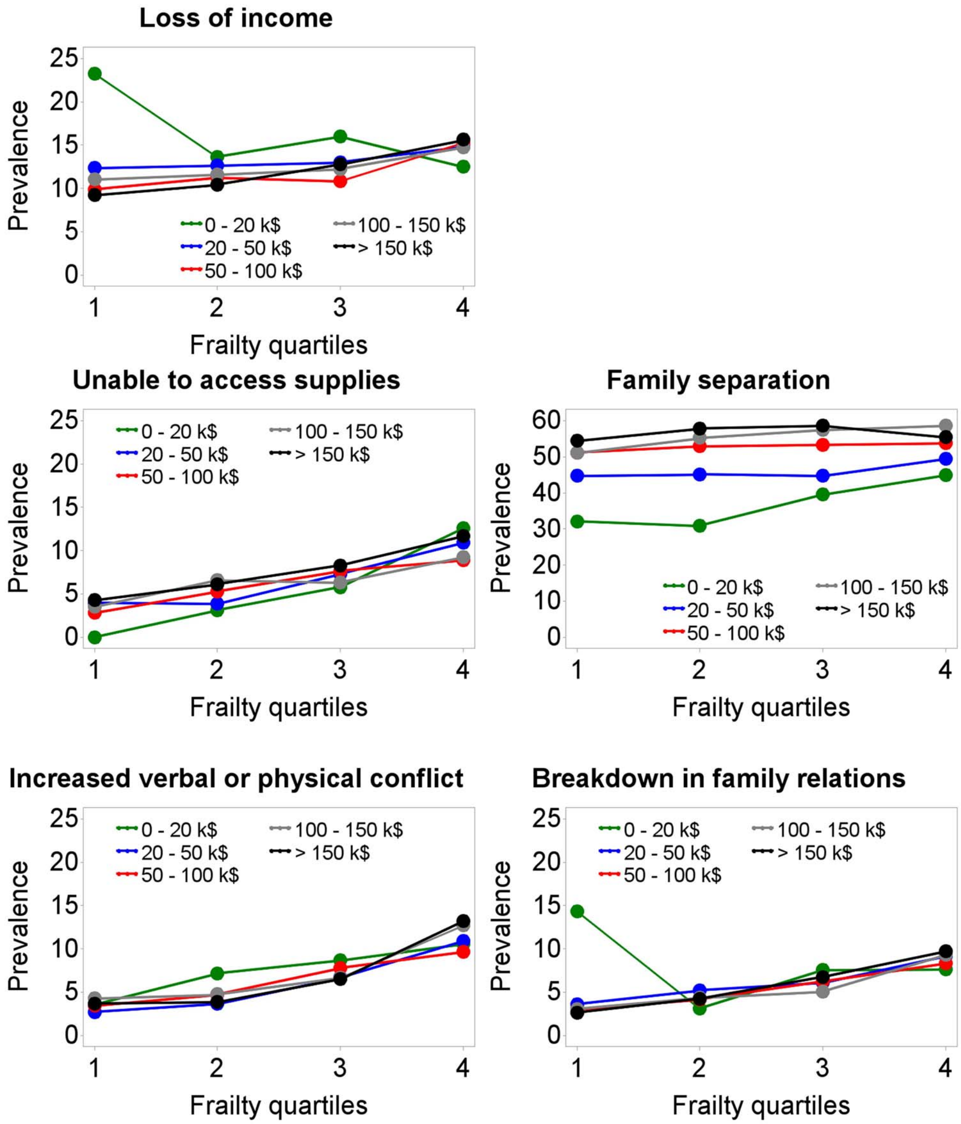

Figure 3. Estimated adjusted prevalence of health, resource, relationship and healthcare access impacts experienced during the COVID-19 pandemic for logistic regression models with a statistically significant interaction between FIQ and pre-pandemic household income in Canadian dollars (CDN) (<$20,000: green, $20,000–$49,999: blue, $50,000–$99,999: red, $100,000–$149,000: grey and ≥ $150,000: black). Interaction models are adjusted for age, sex, marital status, living alone, social participation, smoking status, physical activity and nutritional risk.

impacts especially for healthcare and at higher levels of frailty. Although frailty, instead of age, has been endorsed as a tool to estimate COVID-19 prognosis [12, 40, 49], our data suggest that it may have a broader role in primary care and public health to identify those who may benefit from interventions to reduce the health and social impacts of COVID-19 and future pandemics.

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Declaration of Conflicts of Interest: None.

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