

# A comparison of 3 frailty measures and adverse outcomes in the intake home care population: a retrospective cohort study

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## Abstract

**Background:** In Ontario, Canada, nearly all home care patients are assessed with a brief clinical assessment (interRAI Contact Assessment [interRAI CA]) on admission. Our objective was to compare 3 frailty measures that can be operationalized using the interRAI CA.

**Methods:** We conducted a retrospective cohort study using linked patient-level assessment and administrative data for all Ontario adult ( $\geq 18$  yr) home care patients assessed with the interRAI CA in 2014. We employed multivariable logistic models to compare the Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment (CHESS-CA), Assessment Urgency Algorithm (AUA) and the Frailty Index for the Contact Assessment (FI-CA) that was created for this study. Our outcomes of interest were death, hospital admission and emergency department visits within 90 days, and assessor-rated need for comprehensive geriatric assessment (CGA).

**Results:** In 2014, there were 228 679 unique adult home care patients in Ontario assessed with the interRAI CA. Controlling for age, sex and health region, being in a higher frailty level defined by any measure increased the likelihood of experiencing adverse outcomes. Among all assessments, CHESS-CA was best suited for predicting death and hospital admission, and either AUA or FI-CA for predicting perceived need for CGA. Previous emergency department visits were more predictive of future visits than frailty. Model fit was independent of whether the assessment was completed over the phone or in person.

**Interpretation:** Frailty measures from the interRAI CA identified patients at higher risk for death, hospital admission and perceived need for CGA. In jurisdictions where the CHESS-CA and AUA are already built into the electronic home care platform, such as Ontario, patients identified as high risk should be prioritized for proactive referral and care planning, and may benefit from greater involvement of primary care and other health professionals in the circle of care.

Home care serves people of all ages and with broad complexities of needs. Home care services may be used to support patient recovery after hospital discharge, or to help patients cope with life-limiting illness or manage chronic conditions, disabilities or mental illnesses, among other functions.<sup>1</sup> The availability of community-based care options — in conjunction with substantial contributions by unpaid caregivers — makes it possible to support people with care needs at home, thus reducing demand on high-cost hospital and institutional beds.<sup>2-4</sup> Ultimately, the goal of home care is to meet the patient's needs so that they require the same (or lesser) level of care over time; however, frailty has considerable influence on whether this goal can be achieved.

Frailty describes a state of vulnerability as a result of age-related declines in multiple physiologic systems.<sup>5</sup> When

faced with a stressor, a frail person is more likely to experience sudden health state changes and is less likely to return to their premorbid health state. In this state of poor recovery, frailty increases the risk of adverse outcomes, such as increased dependency and disability, high health service use and death.<sup>5-7</sup> Emerging evidence about coronavirus disease 2019 (COVID-19) suggests that older people and those with comorbidities (especially of the heart, lung, kidney and liver)

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are at the highest risk of severe illness and death, and it is thought that these characteristics may be indicative of underlying frailty.<sup>8–11</sup> It is clear that frailty must be identified early to guide comprehensive care planning to avoid preventable disability and death.

In Ontario, most adult home care patients are assessed with the interRAI Contact Assessment (interRAI CA; about 50 clinical items) upon admission to home care services.<sup>12</sup> About one-third of patients are expected to require services for longer than 2 months and are followed up with the more comprehensive interRAI Home Care assessment (interRAI HC [formerly, RAI-HC]; about 250 clinical items).<sup>13</sup> The interRAI HC produces several frailty measures, including the interRAI Home Care Frailty Scale,<sup>14</sup> Changes in Health, End-stage disease and Signs and Symptoms (CHESS) Scale,<sup>15</sup> and a number of frailty indices.<sup>16,17</sup>

A frailty measure that would apply to all home care patients on admission is needed to support referral and care planning decisions. In this paper, we compare 3 frailty measures that can be operationalized using the interRAI CA based on their relative ability to predict adverse outcomes and assessor-rated need for comprehensive geriatric assessment (CGA).

## Methods

### Study design

We conducted a retrospective cohort study involving adult home care patients in Ontario using linked patient-level assessment and administrative data. The following databases held by the Canadian Institute for Health Information (CIHI) were used in this study: Home Care Reporting System (HCRS) for home care referrals and interRAI CA assessments, Discharge Abstract Database (DAD) for hospital admissions and National Ambulatory Care Reporting System (NACRS) for emergency department visits. Data were linked by CIHI and provided in de-identified form to the University of Waterloo.

### Setting

In Ontario, publicly funded home care is available across the province, although home care programs and services are locally funded, planned and managed by health regions. Any individual can apply for home care services. Care coordinators who are health professionals (often nurses) employed by the health regions receive these referrals and assess the person's needs using the interRAI CA. Existing home care patients returning from hospital are also assessed with the interRAI CA. Care coordinators can complete the assessment by drawing on multiple information sources, such as speaking with the patient or their family (in person or by phone), speaking with other health professionals or care providers and referring to health records or written notes. Once the assessment is complete, standard algorithms are automatically calculated and shown on the patient's dashboard. Previous studies have shown the validity and reliability of the interRAI suite of instruments.<sup>18–22</sup>

### Participants

The study population comprised unique adult ( $\geq 18$  yr) home care patients in Ontario assessed with the interRAI CA between Jan. 1 and Dec. 31, 2014. We selected the most recent interRAI CA if a patient was assessed more than once within the calendar year. Each assessment was linked with the patient's home care referral that was open at the time of assessment and DAD and NACRS records, if available.

### Frailty measures

We selected 3 frailty measures that can be operationalized using the interRAI CA. The assessment items used to construct each of the measures are listed in Appendix 1 (available at [www.cmajopen.ca/content/8/4/E796/suppl/DC1](http://www.cmajopen.ca/content/8/4/E796/suppl/DC1)).

- 1) Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment (CHESS-CA): CHESS-CA is a summary measure of health instability that ranges from 0 (no health instability) to 5 (very high health instability). Although not explicitly named as a frailty scale, it taps key concepts related to frailty (e.g., functional decline) and the CHESS scale from the interRAI HC has been shown to predict health service use, caregiver distress and death among long-stay home care patients.<sup>15,16,23</sup>
- 2) Assessment Urgency Algorithm (AUA): AUA is a risk-screening algorithm that ranges from 1 to 6. Higher AUA levels indicate greater need and priority for a comprehensive follow-up assessment.<sup>12</sup> Patients without cognitive or functional impairment are classified into levels 1 through 3 based on shortness of breath, unstable patterns and poor self-rated health. Patients with any impairment are classified into levels 4 through 6 based on signs of poor personal or family coping.
- 3) Frailty Index for the Contact Assessment (FI-CA): A frailty index counts a person's health deficits across the body's physiologic systems and is expressed as a ratio ranging from 0 to 1.<sup>5</sup> Frailty indices are widely used in primary and community settings, so the index used in this study was considered to be the reference standard.<sup>24–26</sup> In contrast to CHESS-CA and AUA, which are standard interRAI algorithms, FI-CA was created for this study by adapting the Emergency Department Frailty Index (FI-ED), a frailty index that was developed for the Emergency Department version of the Contact Assessment and validated in a multinational cohort.<sup>27</sup> Both the FI-CA and FI-ED count up to 24 deficits, of which 18 deficits are identical in measurement. An additional 6 deficits were added into the FI-CA that satisfy the 5 criteria for creating frailty indices as outlined by Searle and colleagues and are also present in the interRAI Home Care Frailty Scale.<sup>14, 28</sup>

### Outcomes

The following outcomes were extracted if they occurred within 90 days of the assessment date: death based on discharge codes recorded in HCRS, DAD or NACRS; emergency department

visits based on any matching record in NACRS; and non-elective hospital admissions based on any matching record in DAD. An item in the interRAI CA about the assessor's rating of the patient's need for CGA (yes v. no) was used as an additional dependent variable.

### Statistical analysis

Four logistic models were developed for each outcome: first, a base model that included age, sex and health region, and then a model for each frailty measure added to the base covariates. For sensitivity analyses, all models were re-run using alternately sampled or restricted datasets. To enable comparison of FI-CA with the other ordinal measures, we created 6 FI-CA categories that were informed by cut-off points reported in the literature.<sup>29,30</sup> Previous studies have generally adopted the following thresholds: FI < 0.10 (less fit), FI < 0.21 (least fit), FI < 0.45 (frail) and FI ≥ 0.45 (most frail). Other studies propose defining the thresholds based on the sample's FI distribution.<sup>29,30</sup> Brousseau and colleagues<sup>27</sup> suggest defining the most frail groups using the top 25th and 10th percentile scores. Calculation of the area under the curve (AUC) statistics permitted comparison of model goodness of fit. Sociodemographic, health service use and clinical characteristics (used in at least 1 of the frailty measures) are reported in frequency tables. Age-related differences (age ≥ 65 yr v. < 65 yr) were calculated using  $\chi^2$  tests. Spearman rank order correlations were calculated between frailty measures. We used SAS software version 9.4 for all analyses (SAS Institute Inc.).

### Ethics approval

Ethics approval for this research, including the procedures followed to protect privacy and confidentiality, was obtained from the Office of Research Ethics at the University of Waterloo (ORE no. 18228).

## Results

In 2014, there were 228 679 unique adult home care patients in Ontario assessed with the interRAI CA. Table 1 summarizes the sociodemographic and health service use characteristics of the intake home care population. The mean age was 71.8 (standard deviation 15.5) years. Overall, 71.8% of patients were 65 years and older, 57.4% were female, 29.3% lived alone and 96.0% identified a primary informal caregiver. Recent health service use was high: 60.7% of patients had been admitted to hospital in the last 90 days, and 32.6% had visited the emergency department without being admitted to hospital. Similar volumes of patients were assessed in the hospital and community setting. More than half (54.6%) of interRAI CAs were done exclusively over the phone (i.e., without in-person assessment).

Table 2 summarizes the clinical characteristics. Patients who were 65 years and older were significantly more likely to have cognitive and functional impairments, shortness of breath, unstable health patterns and recent falls, whereas patients younger than 65 years reported higher rates of poor

self-rated health, sad or depressed mood, and pain. Patients younger than 65 years were also significantly more likely to have a cancer diagnosis.

Figure 1 shows the distribution of the intake home care population across frailty measures. The distribution varied by the measure used: the 2 highest risk levels accounted for 6.7% (CHESS-CA), 36.5% (AUA) or 26.5% (FI-CA) of the total population. About half (47.5%) of the population was in the 2 lowest CHESS-CA levels. CHESS-CA tended to classify patients with a cancer diagnosis higher than other measures, whereas AUA tended to classify patients with congestive heart failure or Alzheimer disease or related dementia higher than other measures. There was moderate to substantial overlap among the measures. The highest correlation coefficient was observed between AUA and FI-CA (continuous; 0.806,  $p < 0.001$ ). Moderate levels of correlation were observed between CHESS-CA and FI-CA (continuous; 0.622,  $p < 0.001$ ) and CHESS-CA and AUA (0.407,  $p < 0.001$ ).

Overall, 7.3% (16 778) of patients died, 16.6% (38 055) were admitted to hospital and 44.4% (101 526) went to the emergency department within 90 days of the assessment date. Half of the population (114 027; 49.9%) was rated by the assessor as requiring CGA.

Tables 3, 4, 5 and 6 summarize the multivariable logistic models for each study outcome and frailty measure. The CHESS-CA models produced the highest AUC statistics for death (0.768) and hospital admission (0.617). A similar AUC statistic was observed for FI-CA and hospital admission (0.609). Notably, none of the frailty measures were able to improve the prediction of future emergency department visits substantially above the base model. Instead, previous emergency department visits produced the highest AUC statistic for future emergency department visits (0.581). The FI-CA model produced the highest AUC statistic for perceived need for CGA (0.796).

Older age and male sex were consistently associated with greater odds of adverse outcomes, except for negative associations observed between age and emergency department visits and between male sex and need for CGA. In some cases, the odds ratios associated with living in a certain health region were at least as large as the odds ratios for other covariates and even moderate frailty levels. Model fit did not vary significantly when the results were restricted to assessments completed exclusively over the phone. Additional sensitivity analyses showed that the overall results did not change whether a patient's most recent assessment or a randomly selected assessment was used.

To assist with clinical interpretation, Tables 7, 8 and 9 illustrate the observed proportions of each study outcome (where discrimination was possible) by age, sex and frailty measure.

## Interpretation

Among Ontario home care patients assessed with the interRAI CA, 7.3% died, 16.6% were admitted to hospital and 44.4% went to the emergency department within 90 days. Despite a relatively short observation period, these adverse

**Table 1: Sociodemographic and health service use characteristics of the intake home care population**

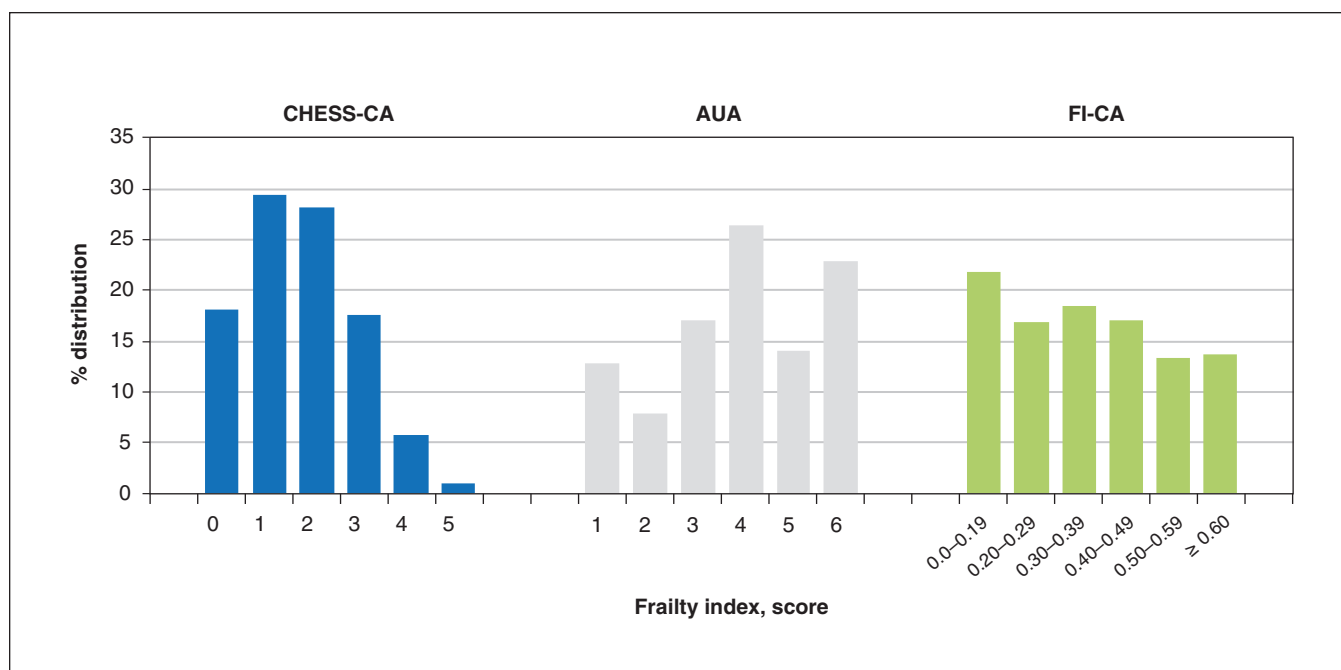
Characteristic	% (no.) of patients		
	All patients <i>n</i> = 228 679	Patients aged < 65 yr <i>n</i> = 64 543	Patients aged ≥ 65 yr <i>n</i> = 164 136
Age group, yr*			
18–49	8.8 (20 209)	31.3 (20 209)	–
50–59	11.3 (25 798)	40.0 (25 798)	–
60–69	18.2 (41 665)	28.7 (18 536)	14.1 (23 129)
70–79	24.4 (55 755)	–	34.0 (55 755)
80–89	28.4 (65 047)	–	39.6 (65 047)
≥ 90	8.8 (20 205)	–	12.3 (20 205)
Sex*			
Female	57.4 (131 217)	54.1 (34 931)	58.6 (96 286)
Male	42.6 (97 462)	45.9 (29 612)	41.3 (67 850)
Living arrangement*			
Alone	29.3 (66 944)	21.5 (13 919)	32.3 (53 025)
With spouse or partner	46.4 (106 142)	53.0 (34 227)	43.8 (71 915)
With other family	16.0 (36 562)	18.3 (11 862)	15.0 (24 700)
With nonrelatives	8.3 (19 031)	7.0 (4535)	8.8 (14 496)
Primary informal caregiver present*			
Yes, spouse or partner	45.7 (104 492)	54.3 (35 089)	42.3 (69 403)
Yes, other relationship	50.3 (115 078)	39.5 (25 527)	54.5 (89 551)
No informal caregiver	4.0 (9109)	6.1 (3927)	3.1 (5182)
Disease diagnoses†			
Congestive heart failure*	7.2 (16 439)	2.4 (1565)	9.0 (14 874)
Chronic obstructive pulmonary disease*	8.7 (19 816)	5.2 (3389)	10.0 (16 427)
Alzheimer disease or related dementia*	7.0 (15 984)	0.6 (355)	9.5 (15 629)
Cancer*	14.3 (32 800)	16.6 (10 715)	13.4 (22 085)
Health service use in last 90 d			
ED visit(s), without hospital admission	32.6 (74 491)	32.8 (21 173)	32.5 (53 318)
Hospital admission(s)*	60.7 (138 829)	62.3 (40 237)	60.0 (98 592)
Patient's location at time of assessment*			
ED or hospital inpatient	48.4 (110 692)	46.12 (29 788)	49.3 (80 904)
Community	46.7 (106 685)	46.5 (30 013)	46.7 (76 672)
Other	4.9 (11 302)	7.3 (4742)	4.0 (6560)
Type of communication at intake*			
Phone only	54.6 (124 939)	57.1 (36 860)	53.6 (88 079)
Other methods‡	45.4 (103 740)	42.9 (27 683)	46.3 (76 057)
Note: ED = emergency department. *Significant difference between age groups ( $p < 0.001$ ). †Estimated based on text mining of free-text diagnoses. ‡Can be any combination of phone, in-person, faxed, written or email communication.			

**Table 2: Clinical characteristics of the intake home care population**

Characteristic	% (no.) of patients		
	All patients <i>n</i> = 228 679	Patients aged < 65 yr <i>n</i> = 64 543	Patients aged ≥ 65 yr <i>n</i> = 164 136
Impaired in cognitive skills*	20.8 (47 645)	10.0 (6503)	25.0 (41 142)
Comprehension, sometimes or rarely or never understands message*	9.5 (21 827)	4.2 (2755)	11.6 (19 072)
Help needed with bathing*	54.8 (125 488)	39.2 (25 314)	61.0 (100 174)
Help needed with personal hygiene*	24.6 (56 393)	15.9 (10 291)	26.2 (43 102)
Help needed with dressing lower body*	38.3 (87 549)	27.4 (17 714)	42.5 (69 835)
Help needed with locomotion, with or without gait aids*	25.0 (57 116)	16.9 (10 911)	28.1 (46 205)
Help with meal preparation*	65.8 (150 526)	53.1 (34 277)	70.8 (116 249)
Help with housework*	77.9 (178 119)	66.7 (43 090)	82.2 (135 029)
Help with managing medications*	34.1 (78 003)	19.8 (12 790)	39.7 (65 213)
Help with managing stairs*	56.1 (128 366)	41.6 (26 861)	61.8 (101 505)
Shortness of breath*	39.9 (91 337)	31.4 (20 301)	43.1 (70 736)
Poor self-reported health*	9.7 (22 170)	12.0 (7737)	8.8 (14 433)
Unstable health patterns, at rest or when performing activities*	52.8 (120 887)	45.0 (29 011)	56.0 (91 876)
Recent decline in cognitive status*	14.4 (32 907)	5.6 (3636)	17.8 (29 271)
Recent decline in functional status*	58.1 (132 878)	49.1 (31 707)	61.6 (101 171)
Sad or depressed mood*	15.5 (35 465)	19.0 (12 252)	14.1 (23 213)
Recent fall(s)*	33.8 (77 352)	23.5 (15 174)	37.9 (62 178)
Dizziness*	16.3 (37 421)	16.8 (10 881)	16.1 (26 540)
Peripheral edema*	32.1 (73 440)	29.4 (19 021)	33.1 (54 419)
Any pain, moderate or severe*	50.1 (114 691)	57.6 (37 168)	47.2 (77 523)
Appetite loss	14.0 (32 054)	14.1 (9149)	14.0 (22 905)
Weight loss*	11.9 (27 205)	11.4 (7378)	12.0 (19 827)
Family or friends feeling overwhelmed*	18.0 (41 328)	10.5 (6803)	21.0 (34 525)

\*Significant difference between age groups ( $p < 0.001$ ).





**Figure 1:** Percent distribution of intake home care population across frailty measures. Note: AUA = Assessment Urgency Algorithm; CHES-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; FI-CA = Frailty Index for the Contact Assessment.

outcomes affected a considerable proportion of the intake home care population and illustrate the need to consider comprehensive, proactive care planning for the broader home care population (i.e., not just long-stay patients). This study shows the potential utility of a frailty algorithm embedded in the intake assessment process for identifying vulnerable individuals early in the home care episode.

We believe that this study provides additional evidence for the validity of all 3 measures (CHES-CA, AUA, FI-CA) and extends their application to all home care clients, regardless of the short- or long-term nature of required services. Controlling for age, sex and health region, being in a higher frailty level defined by any measure consistently increased the likelihood of experiencing adverse outcomes. Among all assessments, CHES-CA was best suited for predicting death and admission to hospital, and either AUA or FI-CA for predicting perceived need for CGA. Often, the best model produced only incremental gains in predictive performance above the next best model.

Previous studies have also identified well-performing measures of frailty despite not finding a single measure that outperforms the rest.<sup>16,31</sup> The AUC statistics observed for death and hospital admission in the CHES-CA and FI-CA models among this study's intake home care population are strikingly similar to those reported for long-stay patients. Hirdes and colleagues observed an AUC statistic of 0.752 in their CHES model after adjusting for age, sex and diagnoses. Campitelli and colleagues observed AUC statistics of 0.607 and 0.600 in their CHES and FI models, respectively, after adjusting for age, sex and comorbidity.<sup>15,31</sup> The intake home care population is relatively younger and has higher levels of

health instability compared to the subset of long-stay patients, yet the frailty measures yielded similar predictive performance. Outside of Ontario, CHES-CA was strongly associated with home care intensity (i.e., ratio of days with home care visits) after older Italian patients were discharged from hospital to home.<sup>32</sup> Taken together, our findings add to existing evidence that these frailty measures can be applied across the home care population, and where compatible measures exist across assessment systems, allow for direct comparisons between populations.

Brousseau and colleagues<sup>27</sup> developed the Emergency Department Frailty Index (FI-ED) out of the interRAI ED-Contact Assessment and found that the FI-ED was significantly associated with hospital admission, hospital death, prolonged hospital stay, discharge to long-term care and perceived need for CGA. As sister instruments, the interRAI ED-CA and interRAI CA share many of the same clinical items, and thus, there is a 75% overlap in the items contained in the FI-ED and FI-CA. It is reasonable, therefore, to expect that the results of these 2 studies apply to patient populations and settings using either assessment instrument.

The lack of a strong relation between frailty and emergency department visits is consistent with other studies of community-dwelling older adults.<sup>33,34</sup> The Detection of Indicators and Vulnerabilities for Emergency department Trips (DIVERT) Scale in the interRAI HC suggests that previous emergency department use, cardiorespiratory symptoms and cardiac conditions are the main drivers.<sup>35</sup> Similarly, in the present study, having an emergency department visit in the last 90 days was a better predictor of future emergency department visits than any frailty measure.

**Table 3: Adjusted odds ratios of death within 90 days of interRAI CA assessment among the intake home care population**

Variable	Adjusted OR (95% CI)*			
	Base model (age, sex, health region only)	CHESS-CA, adjusted for age, sex, health region	AUA, adjusted for age, sex, health region	FI-CA, adjusted for age, sex, health region
CHESS-CA, score				
0		Reference		
1		1.67 (1.53–1.81)		
2		3.02 (2.80–3.27)		
3		6.69 (6.20–7.23)		
4		20.38 (18.01–22.09)		
5		63.21 (56.59–70.61)		
AUA, score				
1			Reference	
2			1.86 (1.64–2.11)	
3			4.22 (3.82–4.66)	
4			3.26 (2.96–3.59)	
5			7.57 (6.87–8.33)	
6			8.24 (7.50–9.05)	
FI-CA, score				
0–0.19				Reference
0.20–0.29				1.71 (1.57–2.85)
0.30–0.39				2.61 (2.42–2.82)
0.40–0.49				3.82 (3.55–4.11)
0.50–0.59				5.81 (5.40–6.25)
≥ 0.60				11.66 (10.88–12.51)
Age group, yr				
18–49	Reference	Reference	Reference	Reference
50–59	1.85 (1.68–2.04)	1.48 (1.34–1.64)	1.83 (1.66–2.03)	1.74 (1.57–1.92)
60–69	2.40 (2.20–2.63)	1.77 (1.61–1.94)	2.32 (2.12–2.54)	2.10 (1.92–2.31)
70–79	2.80 (2.56–3.06)	1.87 (1.71–2.05)	2.43 (2.23–2.66)	2.04 (1.87–2.23)
80–89	3.10 (2.84–3.38)	1.93 (1.76–2.11)	2.40 (2.20–2.62)	1.87 (1.71–2.04)
≥ 90	4.46 (4.06–4.89)	2.64 (2.39–2.90)	3.19 (2.90–3.51)	2.29 (2.08–2.52)
Sex				
Female	Reference	Reference	Reference	Reference
Male	1.62 (1.57–1.68)	1.62 (1.57–1.67)	1.69 (1.63–1.74)	1.68 (1.63–1.74)
Health region				
Central	Reference	Reference	Reference	Reference
West	1.02 (0.98–1.07)	1.17 (1.12–1.22)	1.18 (1.14–1.23)	1.28 (1.23–1.34)
East	0.97 (0.93–1.01)	0.96 (0.92–1.00)	1.00 (0.96–1.05)	1.00 (0.96–1.05)
North	1.02 (0.96–1.09)	1.07 (1.00–1.15)	1.14 (1.06–1.21)	1.20 (1.12–1.28)
Toronto	0.74 (0.68–0.80)	0.95 (0.87–1.03)	0.77 (0.71–0.84)	0.86 (0.79–0.93)
C statistic for all assessments	0.610	0.768	0.691	0.732
C statistic for assessments completed exclusively over the phone	0.630	0.777	0.693	0.733

Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; CI = confidence interval; FI-CA = Frailty Index for the Contact Assessment; interRAI CA = interRAI Contact Assessment; OR = odds ratio.

\*Unless stated otherwise.

**Table 4: Adjusted odds ratios of hospital admission within 90 days of interRAI CA assessment among the intake home care population**

Variable	Adjusted OR (95% CI)*			
	Base model (age, sex, health region only)	CHESS-CA, adjusted for age, sex, health region	AUA, adjusted for age, sex, health region	FI-CA, adjusted for age, sex, health region
CHESS-CA, score				
0		Reference		
1		1.29 (1.24–1.34)		
2		2.73 (2.67–2.80)		
3		2.54 (2.45–2.65)		
4		3.31 (3.15–3.48)		
5		2.35 (2.12–2.61)		
AUA, score				
1			Reference	
2			1.52 (1.43–1.61)	
3			2.07 (1.98–2.17)	
4			1.78 (1.70–1.86)	
5			2.40 (2.29–2.52)	
6			2.70 (2.58–2.83)	
FI-CA, score				
0–0.19				Reference
0.20–0.29				1.24 (1.19–1.29)
0.30–0.39				1.52 (1.46–1.58)
0.40–0.49				1.84 (1.77–1.91)
0.50–0.59				2.22 (2.13–2.31)
≥ 0.60				2.70 (2.59–2.81)
Age group, yr				
18–49	Reference	Reference	Reference	Reference
50–59	1.17 (1.10–1.23)	1.07 (1.01–1.13)	1.15 (1.09–1.22)	1.13 (1.07–1.19)
60–69	1.26 (1.20–1.32)	1.11 (1.06–1.17)	1.23 (1.17–1.30)	1.18 (1.12–1.24)
70–79	1.40 (1.33–1.46)	1.19 (1.13–1.24)	1.31 (1.25–1.37)	1.22 (1.16–1.27)
80–89	1.46 (1.40–1.53)	1.21 (1.15–1.26)	1.31 (1.25–1.37)	1.17 (1.12–1.23)
≥ 90	1.66 (1.57–1.75)	1.33 (1.26–1.41)	1.43 (1.35–1.51)	1.23 (1.17–1.30)
Sex				
Female	Reference	Reference	Reference	Reference
Male	1.36 (1.33–1.39)	1.37 (1.33–1.40)	1.38 (1.35–1.41)	1.38 (1.35–1.41)
Health region				
Central	Reference	Reference	Reference	Reference
West	1.09 (1.06–1.12)	1.14 (1.11–1.17)	1.17 (1.14–1.21)	1.19 (1.15–1.22)
East	1.07 (1.04–1.10)	1.05 (1.02–1.08)	1.09 (1.05–1.12)	1.08 (1.05–1.11)
North	1.19 (1.14–1.24)	1.20 (1.15–1.26)	1.25 (1.20–1.31)	1.27 (1.21–1.33)
Toronto	1.39 (1.33–1.46)	1.51 (1.44–1.59)	1.41 (1.35–1.48)	1.48 (1.41–1.56)
C statistic for all assessments	0.560	0.617	0.598	0.609
C statistic for assessments completed exclusively over the phone	0.565	0.622	0.593	0.604
Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; CI = confidence interval; FI-CA = Frailty Index for the Contact Assessment; interRAI CA = interRAI Contact Assessment; OR = odds ratio. *Unless stated otherwise.				



**Table 5: Adjusted odds ratios of emergency department visit within 90 days of interRAI CA assessment among the intake home care population**

Variable	Adjusted OR (95% CI)*			
	Base model (age, sex, health region only)	CHESS-CA, adjusted for age, sex, health region	AUA, adjusted for age, sex, health region	FI-CA, adjusted for age, sex, health region
CHESS-CA, score				
0		Reference		
1		0.99 (0.97–1.02)		
2		1.14 (1.11–1.16)		
3		1.42 (1.38–1.46)		
4		1.49 (1.43–1.55)		
5				
AUA, score				
1			Reference	
2			1.54 (1.48–1.60)	
3			1.54 (1.49–1.59)	
4			1.03 (1.00–1.06)	
5			1.13 (1.10–1.17)	
6			1.24 (1.20–1.28)	
FI-CA, score				
0–0.19				Reference
0.20–0.29				0.90 (0.87–0.92)
0.30–0.39				0.91 (0.89–0.93)
0.40–0.49				0.94 (0.92–0.97)
0.50–0.59				1.02 (0.99–1.05)
≥ 0.60				1.06 (1.03–1.09)
Age group, yr				
18–49	Reference	Reference	Reference	Reference
50–59	0.98 (0.95–1.02)	0.96 (0.92–0.99)	1.00 (0.96–1.03)	0.99 (0.95–1.02)
60–69	0.90 (0.87–0.93)	0.86 (0.83–0.89)	0.93 (0.90–0.96)	0.90 (0.87–0.93)
70–79	0.81 (0.78–0.83)	0.77 (0.74–0.79)	0.85 (0.82–0.88)	0.80 (0.78–0.83)
80–89	0.70 (0.68–0.72)	0.65 (0.63–0.67)	0.74 (0.72–0.76)	0.69 (0.67–0.71)
≥ 90	0.64 (0.61–0.66)	0.59 (0.57–0.61)	0.68 (0.66–0.71)	0.62 (0.60–0.65)
Sex				
Female	Reference	Reference	Reference	Reference
Male	1.24 (1.22–1.27)	1.25 (1.23–1.27)	1.23 (1.21–1.25)	1.24 (1.22–1.26)
Health region				
Central	Reference	Reference	Reference	Reference
West	1.06 (1.04–1.08)	1.08 (1.05–1.10)	1.07 (1.05–1.10)	1.07 (1.05–1.10)
East	1.13 (1.10–1.15)	1.12 (1.09–1.14)	1.14 (1.11–1.17)	1.13 (1.11–1.16)
North	1.26 (1.21–1.30)	1.26 (1.22–1.30)	1.26 (1.22–1.31)	1.27 (1.22–1.31)
Toronto	1.16 (1.12–1.21)	1.19 (1.15–1.24)	1.14 (1.09–1.18)	1.17 (1.13–1.22)
C statistic for all assessments	0.559	0.570	0.572	0.561
C statistic for assessments completed exclusively over the phone	0.565	0.575	0.580	0.569

Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; CI = confidence interval; FI-CA = Frailty Index for the Contact Assessment; interRAI CA = interRAI Contact Assessment; OR = odds ratio.

\*Unless stated otherwise.

**Table 6: Adjusted odds ratios of perceived need for comprehensive geriatric assessment within 90 days among the intake home care population**

Variable	Adjusted OR (95% CI)*			
	Base model (age, sex, health region only)	CHESS-CA, adjusted for age, sex, health region	AUA, adjusted for age, sex, health region	FI-CA, adjusted for age, sex, health region
CHESS-CA, score				
0		Reference		
1		1.61 (1.57–1.65)		
2		2.64 (2.57–2.72)		
3		4.84 (4.70–5.00)		
4		18.16 (17.11–19.28)		
5		14.38 (12.71–16.27)		
AUA, score				
1			Reference	
2			1.68 (1.60–1.77)	
3			4.18 (4.01–4.35)	
4			6.20 (5.96–6.45)	
5			12.87 (12.33–13.43)	
6			28.27 (27.11–29.49)	
FI-CA, score				
0–0.19				Reference
0.20–0.29				2.02 (1.95–2.09)
0.30–0.39				3.66 (3.55–3.77)
0.40–0.49				7.33 (7.10–7.56)
0.50–0.59				13.54 (13.06–14.04)
≥ 0.60				25.23 (24.21–26.28)
Age group, yr				
18–49	Reference	Reference	Reference	Reference
50–59	1.36 (1.31–1.42)	1.18 (1.13–1.23)	1.34 (1.28–1.40)	1.28 (1.23–1.34)
60–69	1.65 (1.59–1.71)	1.36 (1.31–1.41)	1.56 (1.50–1.63)	1.47 (1.41–1.53)
70–79	2.54 (2.45–2.63)	2.02 (1.94–2.09)	2.10 (2.02–2.19)	1.94 (1.86–2.01)
80–89	4.28 (4.14–4.43)	3.38 (3.26–3.51)	3.13 (3.02–3.26)	2.79 (2.68–2.90)
≥ 90	5.95 (5.70–6.21)	4.61 (4.41–4.82)	3.84 (3.66–4.02)	3.11 (2.96–3.26)
Sex				
Female	Reference	Reference	Reference	Reference
Male	0.92 (0.91–0.94)	0.91 (0.90–0.93)	0.99 (0.97–1.00)	0.96 (0.95–0.98)
Health region				
Central	Reference	Reference	Reference	Reference
West	0.67 (0.66–0.69)	0.69 (0.68–0.71)	0.83 (0.81–0.85)	0.81 (0.79–0.83)
East	0.83 (0.81–0.85)	0.78 (0.76–0.80)	0.84 (0.82–0.86)	0.80 (0.78–0.82)
North	0.70 (0.68–0.73)	0.69 (0.67–0.72)	0.81 (0.78–0.84)	0.80 (0.77–0.83)
Toronto	1.13 (1.09–1.18)	1.31 (1.25–1.36)	1.30 (1.24–1.36)	1.39 (1.33–1.45)
C statistic for all assessments	0.659	0.733	0.791	0.796
C statistic for assessments completed exclusively over the phone	0.655	0.735	0.781	0.785

Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; CI = confidence interval; FI-CA = Frailty Index for the Contact Assessment; OR = odds ratio.

\*Unless stated otherwise.

**Table 7: Observed proportion of death within 90 days of interRAI CA assessment among the intake home care population\***

Variable	% of patients; age group, yr; and sex											
	18–49		50–59		60–69		70–79		80–89		≥ 90	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
<b>CHESS-CA, score</b>												
0	0.6	0.7	1.3	1.0	1.9	1.5	2.3	1.6	4.1	2.1	4.1	4.5
1	1.8	1.1	2.3	2.0	3.2	1.9	3.8	2.7	5.3	3.3	8.3	5.4
2	2.7	1.8	4.9	3.5	6.4	4.2	7.6	4.3	9.0	5.2	12.2	7.5
3	9.5	6.5	11.3	9.9	14.8	9.6	16.4	9.5	15.9	9.3	19.2	13.3
4	35.4	37.9	38.7	31.3	42.7	32.6	35.9	27.9	32.1	19.7	33.7	22.5
5	61.9	57.8	71.4	52.5	62.7	59.4	61.3	57.1	56.2	52.9	62.1	45.2
<b>AUA, score</b>												
1	0.6	0.5	1.4	1.0	1.5	0.6	2.1	1.3	3.6	2.3	5.5	2.9
2	1.1	0.9	2.9	2.3	4.1	2.4	3.5	3.3	5.0	2.8	8.8	3.6
3	4.1	2.7	6.2	5.2	8.8	5.5	9.6	6.1	9.5	4.6	9.0	6.3
4	2.5	2.2	4.7	3.5	6.6	4.3	7.2	4.1	8.2	4.6	9.9	5.0
5	3.9	4.2	9.2	7.8	14.2	9.5	15.7	9.7	15.5	9.9	18.7	13.2
6	8.0	7.1	13.3	9.9	16.5	11.0	16.9	9.9	15.9	8.7	20.1	12.8
<b>FI-CA, score</b>												
0–0.19	0.8	0.8	1.9	1.5	2.4	1.5	2.7	2.1	4.4	2.0	5.9	2.2
0.20–0.29	2.2	1.2	3.4	3.0	4.2	2.6	4.6	3.0	5.7	3.1	5.2	5.2
0.30–0.39	3.0	1.9	5.1	3.7	7.5	4.3	7.7	3.9	7.9	4.3	9.6	4.6
0.40–0.49	4.2	3.5	7.8	5.6	11.7	5.8	11.1	5.8	10.2	5.2	11.9	7.3
0.50–0.59	6.5	6.7	10.9	8.5	13.6	10.9	14.9	9.6	13.8	8.0	15.7	10.0
≥ 0.60	16.2	15.7	26.3	20.9	28.9	20.8	25.0	16.9	21.8	14.3	26.5	17.4

Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; FI-CA = Frailty Index for the Contact Assessment; interRAI CA = interRAI Contact Assessment.

\*The shade of colour in the cells indicates the observed proportion of death, with the lightest shade indicating lowest observed proportion and the darkest shade indicating highest observed proportion.

At the time of writing, both CHESS-CA and AUA are approved interRAI algorithms and can be readily integrated into any interRAI CA implementation. In the interest of using existing decision-support tools, this study provides evidence that use of CHESS-CA and AUA together would give a clear picture about the patient's frailty status. CHESS-CA is a strong predictor of death and should prompt actions that might reduce the risk, such as expediting referrals to a physician or medical team, where appropriate. AUA is better suited for identifying patients requiring CGA (i.e., interRAI HC assessment), especially among patients with chronic or complex needs.

Rather than recommending a single frailty measure for which there is no overwhelming evidence, this study's findings reinforce the use of multiple algorithms as part of the "care planning toolkit."<sup>36</sup> Care coordinators review the areas of concern identified by the algorithms and, applying their clinical expertise, develop a care plan grounded in the patient and family's needs and goals. This approach is consistent with the notion that frailty likely arises from multiple

etiologies, and as such, effective management requires a team of health professionals and an individualized approach to care.<sup>37,38</sup>

In the current COVID-19 pandemic environment, CHESS-CA and AUA combined with syndromic and exposure risk assessment could identify vulnerable people who may benefit from targeted proactive case finding and remote monitoring across primary, acute and continuing care settings. Based on current knowledge that frailty is an important risk factor for severe COVID-19, individuals and their families and their circle of care may be better prepared to engage in goals of care or end-of-life discussions.<sup>39</sup> As a result, early in April 2020, interRAI members from Canada, South Africa and Finland developed a brief self-reported instrument called the interRAI COVID-19 Vulnerability Screener (CVS) that calculates AUA among other outputs.<sup>40</sup> Future research should evaluate the association between AUA and adverse outcomes related to COVID-19 disease among those assessed with either the interRAI CA or interRAI CVS.

**Table 8: Observed proportion of hospital admission within 90 days of interRAI CA assessment among the intake home care population\***

Variable	% of patients; age group, yr; and sex											
	18–49		50–59		60–69		70–79		80–89		≥ 90	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
CHESS-CA, score												
0	9.6	9.4	10.0	9.2	11.1	9.1	12.4	8.4	14.6	10.6	14.9	13.5
1	10.9	11.1	14.1	11.1	14.0	10.1	15.8	11.7	17.4	12.8	20.6	14.9
2	15.3	13.9	17.1	13.5	19.1	14.5	20.5	14.6	22.0	15.5	24.4	17.3
3	24.0	20.7	24.6	21.4	26.3	21.5	28.3	21.6	26.6	19.4	27.4	21.9
4	36.5	37.9	35.6	35.0	35.5	30.4	31.2	28.3	29.5	22.8	24.6	22.5
5	28.6	35.6	27.5	24.8	26.7	32.1	25.8	26.0	18.8	15.8	16.4	11.9
AUA, score												
1	8.4	8.9	8.9	7.2	9.1	7.4	11.1	7.3	13.0	9.5	14.4	10.8
2	13.2	11.4	13.4	11.2	15.1	11.7	15.4	11.5	17.1	11.4	12.9	13.0
3	16.4	15.7	19.6	15.0	21.0	15.6	21.5	15.5	20.2	13.0	21.3	12.5
4	12.3	11.0	14.3	13.1	15.7	12.9	18.1	13.5	19.7	14.1	22.5	15.8
5	10.9	14.0	18.1	17.8	21.3	17.1	23.9	18.6	24.0	18.7	22.6	19.1
6	16.7	16.0	23.3	19.2	26.0	20.0	25.8	19.5	24.8	17.8	26.8	20.4
FI-CA, score												
0–0.19	10.2	9.9	11.6	9.6	11.8	9.7	12.9	9.3	15.2	9.9	16.9	10.3
0.20–0.29	13.4	12.2	13.9	10.3	15.0	10.9	16.1	11.2	17.0	12.3	16.5	14.4
0.30–0.39	14.5	13.1	17.1	13.6	18.3	13.0	19.8	14.2	18.9	13.3	22.0	14.9
0.40–0.49	15.1	14.4	20.7	15.6	23.1	16.1	22.6	15.9	22.0	15.5	22.9	18.2
0.50–0.59	15.0	19.0	21.4	23.4	24.4	21.8	25.9	19.5	24.6	17.8	24.9	18.0
≥ 0.60	21.1	20.8	28.9	25.5	29.7	24.9	28.3	24.0	27.1	21.3	26.6	21.5

Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; FI-CA = Frailty Index for the Contact Assessment; interRAI CA = interRAI Contact Assessment.

\*The shade of colour in the cells indicates the observed proportion of hospital admission, with the lightest shade indicating lowest observed proportion and the darkest shade indicating highest observed proportion.

## Limitations

Compared with other studies focused on Ontario long-stay home care patients, our study includes all home care patients in the province, contributing to its generalizability. Patient-level linkage of HCRS, DAD and NACRS databases based on unique patient identifiers and exact assessment and event dates enables us to have high confidence in the rates of hospital admissions and emergency department visits.

Several limitations should be noted. In the present study, we created the FI-CA for use as the reference standard for frailty measurement based on the accumulation of deficits principle. Although the FI-CA made it possible to directly compare the results from a widely accepted conceptualization of frailty with other algorithms, it is important to note that the FI-CA itself has not been tested or validated beyond this study. Second, deaths were identified from the discharge disposition found in home care and hospital administrative records. If the patient moved to another setting (e.g., long-term care facility) and died in that setting within the 90-day period, the discharge dispo-

sition would not be revised retroactively, resulting in under-reporting of actual deaths. Nevertheless, the AUC statistics and relative differences in the odds ratios for death between the frailty levels were consistent with those of previous studies.

Third, although the interRAI CA is completed by a trained health professional, some questions, such as changes in cognition or activities of daily living status in the last 90 days, are prone to self-report and recall biases. The presence of these biases reinforce the importance of using the full “care planning toolkit” and viewing the patient’s health status as a whole rather than relying on a single indicator.

## Conclusion

Frailty measures (CHESS-CA, AUA, FI-CA) from the interRAI CA identified patients at higher risk for death and hospital admission within 90 days and those perceived to benefit from comprehensive follow-up assessment. The frailty measures added little to the prediction of emergency department visits. CHESS-CA and AUA are standard algorithms already

**Table 9: Observed proportion of perceived need of comprehensive geriatric assessment among the intake home care population\***

Variable	% of patients; age group, yr; and sex											
	18–49		50–59		60–69		70–79		80–89		≥ 90	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
CHESS-CA, score												
0	18.4	19.7	20.7	20.8	21.7	21.4	27.1	29.5	38.1	41.9	45.2	48.9
1	24.5	25.2	25.8	27.3	29.0	30.6	36.5	42.4	50.6	55.1	60.3	63.2
2	31.7	34.8	36.6	39.3	39.0	42.1	50.7	52.7	64.7	66.4	72.6	73.2
3	46.2	48.0	53.2	52.7	57.4	59.4	67.0	67.3	76.3	76.1	82.2	82.0
4	83.7	83.8	87.9	87.0	89.1	89.3	89.1	89.2	90.5	89.6	88.1	87.0
5	85.7	75.6	89.0	85.2	88.9	89.1	86.3	85.8	85.6	84.5	86.2	83.6
AUA, score												
1	8.4	9.2	10.1	9.9	9.1	8.3	11.2	11.2	18.9	18.3	27.8	23.4
2	11.9	13.7	16.3	14.9	16.4	17.0	18.8	20.5	22.3	25.2	31.3	28.8
3	29.5	27.8	34.9	32.8	36.1	34.5	37.2	36.2	42.5	40.5	48.1	44.1
4	27.4	28.8	33.3	33.5	36.8	38.8	45.1	49.7	58.2	61.9	67.2	67.8
5	36.3	42.9	48.8	53.7	60.8	61.4	69.6	69.3	75.7	75.1	74.9	73.3
6	63.5	63.6	70.7	69.2	76.5	74.5	83.4	81.6	87.8	86.4	89.9	89.3
FI-CA, score												
0–0.19	12.5	13.3	15.1	14.7	14.6	15.1	16.3	18.0	22.9	25.1	27.4	32.4
0.20–0.29	21.5	22.6	25.0	23.0	25.4	25.7	30.0	31.9	38.1	41.3	46.0	48.0
0.30–0.39	30.5	30.2	36.1	35.0	38.9	37.3	43.5	46.5	54.2	57.0	62.4	62.7
0.40–0.49	41.9	45.3	52.3	51.2	57.0	55.0	63.0	63.2	71.1	73.2	75.8	73.3
0.50–0.59	52.9	59.4	63.9	67.4	71.7	74.3	77.3	79.6	81.7	81.5	82.5	79.5
≥ 0.60	71.4	72.8	79.4	79.3	84.7	84.4	88.7	87.8	90.1	88.1	87.5	86.6

Note: AUA = Assessment Urgency Algorithm; CHESS-CA = Changes in Health, End-stage disease and Signs and Symptoms Scale for the Contact Assessment; FI-CA = Frailty Index for the Contact Assessment.

\*The shade of colour in the cells indicates the observed proportion of perceived need for comprehensive geriatric assessment, with the lightest shade indicating lowest observed proportion and the darkest shade indicating highest observed proportion.

embedded into the interRAI CA that offer decision support within existing systems. These measures offer quick identification of frail home care patients at admission (and the general population that could be assessed with the interRAI CVS) who face increased risk during regular times but are particularly vulnerable during a disease outbreak.

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