The impact of social vulnerability on the survival of the fittest older adults

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Abstract

Background: even older adults who are fit experience adverse health outcomes; understanding their risks for adverse outcomes may offer insight into ambient population health. Here, we evaluated mortality risk in relation to social vulnerability among the fittest older adults in a representative community-dwelling sample of older Canadians.

Methods: in this secondary analysis of the Canadian Study of Health and Aging, participants (n = 5,703) were aged 70+ years at baseline. A frailty index was used to grade relative levels of fitness/frailty, using 31 self-reported health deficits. The analysis was limited to the fittest people (those reporting 0–1 health deficit). Social vulnerability was trichotomised from a social vulnerability scale, which consisted of 40 self-reported social deficits.

Results: five hundred and eighty-four individuals had 0–1 health deficit. Among them, absolute mortality risk rose with increasing social vulnerability. In those with the lowest level of social vulnerability, 5-year mortality was 10.8%, compared with 32.5% for those with the highest social vulnerability (adjusted hazard ratio 2.5, 95% CI: 1.5–4.3, P = 0.001).

Conclusions: a 22% absolute mortality difference in the fittest older adults is of considerable clinical and public health importance. Routine assessment of social vulnerability by clinicians could have value in predicting the risk of adverse health outcomes in older adults.

Keywords: frailty, survival, mortality, frail elderly, aged, social vulnerability, elderly

Introduction

At any age, on average, older people have more health deficits (broadly defined to include illnesses, symptoms and functional limitations) than do younger people. Even so, some people live into old age having accumulated very few health deficits. This group of apparently very healthy elderly people is of some interest. In particular, they might offer some insight into the overall health of a population. This is because in the absence of known problems with
their own health (intrinsic factors), the health and mortality outcomes of these fittest people of a society may depend rather on extrinsic factors such as the attributes of that society and the environment in which it is located.

The age-related accumulation of health deficits can shed some insights on frailty, i.e. on the problem of heterogeneity in health outcomes of people of the same chronological age. Health deficits are defined broadly, to include symptoms, signs, diseases, disabilities or laboratory abnormalities. A number of studies have found that the more deficits that people have the more likely they are to experience adverse health outcomes, such as death, institutionalisation or worsening in their health [1–7]. This relationship to adverse health outcomes is true across the entire range of health deficits, so that people in whom deficits are not demonstrable (whom we refer to as being in the ‘zero state’ of frailty) have the lowest rate of death, institutionalisation and worsening health.

Social conditions, including socio-economic status, social support, social engagement and mastery, have powerful influences on health [8–13]. However, the influence of social factors such as socio-economic status in older age is debated [14–16]. Nevertheless, we have previously reported results from both the Canadian Study of Health and Aging (CSHA) and the National Population Health Survey showing that a holistic social vulnerability index, akin to the frailty index, which includes social factors from various domains including socio-economic status, social support, social engagement and mastery, predicts both mortality and cognitive decline among older adults [17, 18]. Here, our objective was to investigate the impact of social vulnerability, quantified using a social vulnerability index, on the survival of only the fittest older adults, defined using a frailty index.

Methods

Ethics statement

Ethical approval was obtained from the ethics committees of each of the 18 CSHA study centres. Written, informed consent for participation in the CSHA was obtained from each participant or proxy respondent.

The sample came from the second phase of the CSHA-2 (conducted in 1996–97). The CSHA is a representative study of dementia and other health problems in older Canadians aged 65 and older [19]. At baseline (CSHA-1, 1990–91), participants (n = 10,263, of whom 9,008 were community dwelling) were sampled in a population-representative manner from English- and French-speaking older Canadians, though those living in the Yukon or Northwest Territories, residents of Aboriginal Reserves or military bases, and those with an immediately life-threatening illness were excluded. The sample was clustered within five Canadian regions and stratified by age, with over-sampling of those aged 75 and older. The baseline data collection occurred in 1991, with follow-up by interview and/or clinical examination or vital status verification at 5 (CSHA-2) and 10 (CSHA-3) years [19]. Of 5,703 participants in the CSHA-2 screening interview, 729 (13%) were missing frailty status. People with missing frailty data were older (83.2 versus 78.5 years, P < 0.0001), often relying on proxy respondents. The fittest individuals were defined as the 584 who were in the ‘zero state’ of frailty, i.e. those in whom either 0 or only 1 health deficit were reported. Of these, 541 (93%) had social vulnerability status data allowing for a social vulnerability index to be calculated. The cohort was followed for 5 years, at which time vital status was known for all but 3 of these 541 individuals; 95 (17.6%) had died.

Frailty and social vulnerability were based on self-report. The social vulnerability index has been described in detail elsewhere [17]. It includes 40 items addressing various social domains including living situation, marital status, social engagement, social support, feelings of mastery and empowerment and socio-economic status. Our previous investigations of its properties have supported its use as a holistic measure; in particular, no single item or group of items has been found to drive associations with health outcomes [17, 18]. Responses to 40 social variables were assigned a value of ‘1’ if representing a deficit and ‘0’ otherwise. The sum of this deficit count, divided by 40, is the social vulnerability index, so that the theoretical range is from 0 (none of the 40 social deficits) to 1 (all 40/40 social deficits); higher scores indicate greater vulnerability [17]. Social vulnerability was divided into tertiles of low, intermediate and high index values. Individuals missing data for one or two of the social deficits were assigned to the tertile of social vulnerability based on their existing data. The 43 individuals who were missing more than one to two variables were coded as missing social vulnerability status and therefore excluded from further analysis.

The frailty index was operationalised using 31 health deficits (illnesses, symptoms and functional problems). Both the frailty and social vulnerability indices have been validated and lists of their constituent variables have been published [6, 17]. The association between level of social vulnerability (independent variable) and mortality (dependent variable) was analysed using Cox regression. The absolute risk of mortality was calculated for the three strata of social vulnerability, and Kaplan–Meier survival curves were generated.

Exercise, smoking and alcohol histories were obtained from a self-reported questionnaire conducted at the first phase of CSHA, 5 years prior to the baseline data for this analysis. These variables were not updated in later phases of the CSHA, so previous reported history is all that was available. Exercise was categorised as high (regular exercise, three or more times per week, more intense than walking), intermediate (regular exercise but either less frequent or of walking intensity or less) and low (no regular exercise reported). This definition of exercise has been validated in the CSHA [20, 21]. Smoking was defined as a lifetime history of ever having ‘smoked cigarettes, pipe or cigars regularly (nearly every day)’. Alcohol intake was similarly defined as ever having been a regular drinker of beer, wine or spirits.

Results

Of 4,974 people with known frailty status, 584 (12%) reported only 0 or 1 deficit. Compared with those with two
or more health deficits, those in the zero state sample were younger (76.3 versus 78.8 years old), less likely to be currently married (43.2 versus 52.6%) and they had slightly higher MMSE scores (27.1 versus 26.7) and more education (11.3 versus 10.5 years; all $P < 0.001$). Fewer women (46.8 versus 61.6%; $P < 0.001$) were in the zero state group. The fittest individuals were more likely to report both exercising ($P < 0.001$) and alcohol consumption ($P = 0.009$). There was no difference in smoking history.

Demographic and lifestyle characteristics of the zero-state group by level of social vulnerability are presented in Table 1. Those with high social vulnerability were older, less likely to be married, and had lower educational attainment and MMSE scores. There were no differences in the lifestyle factors. Adjusting for age and sex, high social vulnerability was associated with an increased risk of death (HR: 2.5, 95% CI: 1.5–4.3, $P = 0.001$) (Figure 1). Among those in the zero state of frailty, the absolute risk of mortality rose with increasing social vulnerability. Among those with low social vulnerability, 32 of 296 died (10.8%), when compared with 37 of 165 (22.4%) with intermediate social vulnerability. In the high social vulnerability group, 26 of 80 (32.5%) had died within 5 years.

Previously reported exercise, previous history of smoking and previous alcohol intake were not statistically significantly associated with mortality among those in the zero state of frailty. In the survival models adjusted for these lifestyle covariates as well as age and sex, the association between high social vulnerability and mortality was strengthened (HR: 3.22, 95% CI: 1.80–5.78, $P < 0.001$).

### Discussion

We found that, among the fittest Canadian older adults, the third with the highest social vulnerability were more than twice as likely to die as the third with the lowest social vulnerability. This increase in risk represents a 22% absolute mortality difference between those with low and high social vulnerability.

While these findings are limited by being based on a single, relatively small sample of older adults, the effect size is striking and warrants further investigation. In particular, replication in samples from countries in different stages of development may be instructive. In addition, possible gender differences and the respective impact of mid-life versus older age social conditions especially warrant further inquiry. The use of self-report data is a further limitation of this study, although we have shown, in relation to the frailty index, that self-report, observer assessed and test data give comparable estimates in the average rate of deficit accumulation and in the maximum observed values [5]. Moreover, for social vulnerability, it

![Figure 1. Kaplan–Meier curves showing survival those in the zero state of frailty (having 0–1 health deficit) by level of social vulnerability (low, intermediate and high). SV, social vulnerability.](image)

### Table 1. Baseline demographic and lifestyle factors according to level of social vulnerability in the ‘zero-state’ sample (those with 0–1 health deficit)

<table>
<thead>
<tr>
<th></th>
<th>Low social vulnerability ($n = 296$)</th>
<th>Intermediate social vulnerability ($n = 265$)</th>
<th>High social vulnerability ($n = 80$)</th>
<th>Statistical significance of differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: mean (SD)</td>
<td>75.2 (4.9)</td>
<td>76.7 (5.4)</td>
<td>77.9 (5.5)</td>
<td>$P &lt; 0.001$</td>
</tr>
<tr>
<td>Sex: % female (%)</td>
<td>45.6</td>
<td>43.6</td>
<td>52.5</td>
<td>$P = 0.42$</td>
</tr>
<tr>
<td>Education: mean (SD) years</td>
<td>12.0 (3.7)</td>
<td>10.9 (3.9)</td>
<td>9.8 (3.6)</td>
<td>$P &lt; 0.001$</td>
</tr>
<tr>
<td>Marital status: % married (%)</td>
<td>73.3</td>
<td>46.1</td>
<td>26.3</td>
<td>$P &lt; 0.001$</td>
</tr>
<tr>
<td>MMSE score: mean (SD)</td>
<td>27.7 (2.3)</td>
<td>27.3 (2.2)</td>
<td>26.7 (2.7)</td>
<td>$P = 0.001$</td>
</tr>
<tr>
<td>History of smoking (asked 5 years previous) (%)</td>
<td>52.6</td>
<td>51.8</td>
<td>60.0</td>
<td>$P = 0.53$</td>
</tr>
<tr>
<td>Alcohol consumption (asked 5 years previous) (%)</td>
<td>49.8</td>
<td>46.8</td>
<td>34.4</td>
<td>$P = 0.09$</td>
</tr>
<tr>
<td>Exercise (asked 5 years previous) (%)</td>
<td>Regularly, &gt;3/week, more intense than walking</td>
<td>24.8</td>
<td>22.9</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>Regularly but less frequent and/or less intense</td>
<td>57.1</td>
<td>56.2</td>
<td>52.5</td>
</tr>
<tr>
<td>No regular exercise</td>
<td>18.1</td>
<td>20.8</td>
<td>26.2</td>
<td></td>
</tr>
</tbody>
</table>
may be that self-perception of one’s social circumstances is particularly important.

Frailty and social vulnerability status were missing for some of the CSHA cohort. Those who were missing these indices were older and had more illnesses than those with complete data. They more often relied on proxy reports, making collection of many self-report items impossible. This is unlikely to have affected the findings of the current study, because the cohort was limited to those in the ‘zero state’ of frailty, who had 0 or 1 health deficit, because those with missing full frailty index data generally had many health problems. However, it is possible that the exclusion of the 43 individuals (7.4% of the zero state sample) who were known to be in the zero state of frailty but were missing social vulnerability status may have affected the analysis of the association between social vulnerability status and health.

The lifestyle data were collected 5 years prior to the current baseline data, and we have no means of verifying whether the previous self-reports correlate with current behaviour, although they do correlate with outcomes [20, 21]. Nevertheless, it is interesting to note that the association between social vulnerability and mortality that we have identified seems to be robust to an initial consideration of confounding by lifestyle factors, though the influence of health-related behaviours on the association between social circumstances and health in older people remains an area for further investigation.

The influence of social factors, usually limited to consideration of socio-economic status, on health in older age has been debated. A recent US study found that socio-economic differences in mortality became insignificant at older ages (ages 70 years and older); this was felt to relate to important differences in health and mortality experienced at earlier ages, possibly leading to a ‘survival of the fittest’ phenomenon [15]. In the Whitehall studies in the UK, the magnitude of association between occupational status and health was found to diminish after retirement, while the importance of other socio-economic indicators was maintained [16]. Others have argued that while the importance of more limited indicators of SES such as income and education may diminish at older ages, consideration of other factors such as financial assets remains important [14]. These sorts of findings have contributed to discussion of how to best measure SES in older age, where occupational status, income and education may have more limited import due to retirement, pension schemes and cohort educational norms [22]. Here, we have broadened our consideration of social factors to create a more holistic representation of aggregate social circumstances, not limited to consideration of a few socio-economic factors, which may explain the differences between our findings and some previous literature reports.

The outcomes of people in the zero state of frailty are of considerable interest. That is because changes in the health of individuals are the sum of ambient changes, plus changes associated with their given state of health [23]. Although mortality outcomes will always be higher as people grow older, the environment will undoubtedly be important—the mortality of the fittest older adults in Somalia, for example, will be higher than that of their counter-parts in Saskatchewan. The outcomes of people in the zero state of frailty provide a quantitative estimate of these background effects, an application of considerable potential. For example, the chance of dying for an individual with three health deficits is a function of the chance of the healthiest people dying—those in the zero state—plus the chance of dying as the number of deficits increases to three [23].

Older people who have aged without accumulating health deficits can be considered examples of healthy ageing. Study of this group of individuals presents an important opportunity to understand predictors and facilitators of healthy ageing, which could in turn lead to new ideas about how to improve the health and quality of life of our ageing populations.

Investigating how social factors affect the healthiest gives a quantitative estimate of those influences on the ambient health of the population. Limiting the analysis to the fittest individuals may allow for improved isolation of what factors in a society make it healthy or unhealthy. We suggest that survival in the zero state of frailty is a candidate marker for the health of populations.

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**Key points**

- Changes in the health of individuals result from both intrinsic and extrinsic factors.
- Studying the fittest older people allows for investigation of extrinsic vulnerability related to social circumstances.
- Social vulnerability captures the degree to which a person’s social situation leaves them susceptible to further insults.
- Among the fittest and healthiest older adults, social vulnerability meaningfully influences survival.
- The survival of the fittest older adults is of potential interest as a candidate marker for the health of populations.

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**Conflicts of interest**

K.R. has applied for funding to commercialise a version of the frailty index based on electronic capture in a comprehensive geriatric assessment.

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Self-rated health and physician-rated health as independent predictors of mortality in elderly men

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