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Original Study

Excess Mortality After COVID-19 in Swedish Long-Term Care Facilities

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A B S T R A C T

Objective: To compare 30-day mortality in long-term care facility (LTCF) residents with and without COVID-19 and to investigate the impact of 31 potential risk factors for mortality in COVID-19 cases.
Design: Retrospective cohort study.
Setting and Participants: All residents of LTCFs registered in Senior Alert, a Swedish national database of health examinations in older adults, during 2019-2020.
Methods: We selected residents with confirmed COVID-19 until September 15, 2020, along with time-dependent propensity score–matched controls without COVID-19. Exposures were COVID-19, age, sex, comorbidities, medications, and other patient characteristics. The outcome was all-cause 30-day mortality.
Results: A total of 3731 residents (median age 87 years, 64.5% female) with COVID-19 were matched to 3731 controls without COVID-19. Thirty-day mortality was 39.9% in COVID-19 cases and 5.7% in controls [relative risk 7.05, 95% confidence interval (CI) 6.10-8.14]. In COVID-19 cases, the odds ratio (OR) for 30-day mortality was 2.43 (95% CI 1.56-3.79) in cases aged 80-84 years, 2.98 (95% CI 1.92-4.64) in cases aged 85-89 years, and 3.26 (95% CI 2.09-5.06) in cases aged ≥90 years, as compared with cases aged <70 years. Other risk factors for mortality among COVID-19 cases included male sex (OR, 2.56, 95% CI 2.19-3.00), neuropsychological conditions (OR, 2.18; 95% CI 1.75-2.70), impaired walking ability (OR, 1.46, 95% CI 1.19-1.80), urinary and bowel incontinence (OR 1.50, 95% CI 1.22-1.85), diabetes (OR 1.36, 95% CI 1.14-1.62), chronic kidney disease (OR 1.37, 95% CI 1.11-1.69) and previous pneumonia (OR 1.57, 95% CI 1.32-1.85). Nutritional factors, cardiovascular diseases, and antihypertensive medications were not significantly associated with mortality.
Conclusions and Implications: In Swedish LTCFs, COVID-19 was associated with a large excess in mortality after controlling for a large number of risk factors. Beyond older age and male sex, several prevalent clinical risk factors independently contributed to higher mortality. These findings suggest that reducing transmission of COVID-19 in LTCFs will likely prevent a considerable number of deaths.

Early in the coronavirus disease 2019 (COVID-19) pandemic, long-term care facilities (LTCFs) were pointed out as high-risk environments, requiring high priority for prevention and precaution.[1] In spite of this, many countries have reported a considerable proportion of COVID-19–related deaths in LTCFs.[2–5] In Sweden, 50% of all deaths have occurred in LTCFs.[6] Sweden has also had a much higher rate of COVID-19 mortality in LTCFs than neighboring countries, being 5-fold higher than in Denmark and 11-fold higher than in Norway and

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Finland.[7] In line with this observation, an independent committee of inquiry appointed by the Swedish government concluded that Sweden's strategy to protect older adults living in LTCFs has failed.[8] Thus, as the world continues to battle new waves of the pandemic, it is imperative to identify the most important risk factors for COVID-19 mortality in countries where mortality has been high in LTCFs, such as in Sweden, so that premature deaths can be prevented.

Although previous research has identified male sex, older age, and comorbidity as risk factors for severe COVID-19 in the general population,[9–14] data from LTCF residents are lacking. Other than a few small studies,[15–18] only 1 large study has investigated risk factors for 30-day mortality following COVID-19 in LTCF residents.[19] Strong risk factors in this study, apart from older age and male sex, were diabetes, chronic kidney disease, and impaired physical and cognitive function.[19] Yet, the median age was only 79 years, and the study did not include a control group, highlighting that more studies in large, representative populations of LTCF residents are warranted. The aim of the present cohort study was to compare all-cause, 30-day mortality in COVID-19 cases and matched controls living in Swedish LTCFs. An additional aim was to also investigate the impact of 31 potential risk factors for all-cause 30-day mortality in COVID-19 cases.

Methods

Study Design and Population

This retrospective cohort study was approved by the Swedish Ethical Review Authority (no. 2020-02552), who waived the informed consent requirement. We considered for inclusion all residents of LTCFs in Sweden who are registered in the Senior Alert database. Launched in 2008, Senior Alert collects data for assessment and prevention of falls, pressure ulcers, malnutrition, and oral health among adults aged ≥65 years.[20] It is used in hospital wards, home care services, and LTCFs in 90% of Swedish municipalities and regions.[20] An estimated 73% of all Swedish LTCF residents are registered in the database.[21]

In the Senior Alert cohort, we identified all COVID-19 cases confirmed in Sweden until mid-September 2020 using the Swedish Public Health Agency's SmiNet database. Reporting confirmed COVID-19 cases to SmiNet is required by law. No information regarding the method of testing was available. COVID-19 cases were excluded from the analysis if they did not have a record in Senior Alert within a year prior to the date of COVID-19 testing or diagnosis (whichever came first or was available). Cases were also excluded if the dates of testing and diagnosis were both unavailable. Persons in the Senior Alert cohort who did not have confirmed COVID-19 (i.e., controls) were included if they had a Senior Alert record in 2019 or 2020 (they were included from the latest record during these years, if there were multiple records).

The data were linked using Personal Identification Numbers, which all residents of Sweden have. Statistics Sweden replaced these numbers with pseudo-anonymized identifiers for integrity reasons.

Risk Factors and Outcome

The study outcome was all-cause, 30-day mortality, which was obtained from the Swedish Cause of Death Register.[22] Body mass index (BMI, weight in kilograms divided by height in meters squared) was obtained from Senior Alert and was used to define underweight (<18.5), normal weight 18.5-24.99), overweight (25.0-29.99), and obesity (≥30). Senior Alert also provided data from 3 validated instruments, which were incorporated into the database upon the advice of an expert panel: Mini Nutritional Assessment, Downton Fall Risk Index, and Modified Norton Scale.[20] The items we selected from these instruments are neuropsychological conditions, known previous falls, walking ability, fluid intake, food intake, incontinence, and general physical condition (Table 1).

Data on comorbidities were obtained from the Swedish National Patient Register (NPR), which includes all diagnoses made in Swedish inpatient care since 1987 and all secondary care since 2001. The NPR has been validated, and most diagnoses have a positive predictive value of at least 90% but lower sensitivity.[23] Data on cancer were obtained from both the NPR and, for the years 1964-2018, the Swedish Cancer Registry. This registry includes all cancer diagnoses made in Sweden since 1958. Data on medication use were collected both from Senior Alert and the Swedish Prescribed Drug Register (PDR), which records all prescription medications dispensed at pharmacies in Sweden since July 2005. For this study, we included only recent medication use, defined as prescriptions collected during 2019-2020. Definitions of diagnoses and medications are available in Supplementary Table 1.

Statistical Analysis

COVID-19 cases and controls were 1:1 matched using time-dependent propensity scores. This method enables matching when the exposure (here, COVID-19) does not coincide with the time of cohort entry (here, the date of the Senior Alert record).[24,25] This was done by running a Cox regression on all potential risk factors, with COVID-19 as the outcome variable and the date of the Senior Alert record as the time origin. This model was used to calculate a propensity score (the linear predictor), reflecting each individual's probability of contracting COVID-19. Next, each COVID-19 case was matched to the control with the closest propensity score among those who were still alive at the time when the COVID-19 case occurred (time was counted as days since the Senior Alert date). Matching was done sequentially, starting with the first COVID-19 case (in terms of days since cohort entry), then the second, and so on. Controls could only be matched to 1 case, and ties in propensity scores were resolved using random selection. Owing to the relatively small number of COVID-19 cases, we did not match later-diagnosed cases as controls to earlier-diagnosed cases, which is commonly done.[24,25] To ensure close matches, a caliper of 1/10th of the standard deviation of the propensity score was used.[26] The Cox regression model included time-varying covariates for diagnoses and medications, meaning that a new propensity-score was calculated for controls at the time each case occurred. After matching, the baseline date was set to the COVID-19 date in cases and the corresponding date (in days since cohort entry) in controls.

In the matched cohort, we calculated the relative risk of all-cause 30-day mortality, with a 95% confidence interval (CI) calculated using the Mantel-Haenszel approach.[27(pp284-286)] In COVID-19 cases, we used logistic regression to calculate unadjusted and fully adjusted odds ratios for mortality and 95% CIs. Furthermore, the fully adjusted model was rerun with age as a continuous variable to estimate the absolute risk of death by age and other characteristics. We used fractional polynomials to accommodate potential nonlinearity for the age variable.

In the regression models, extreme values for height (<130 cm and >200 cm) and weight (<30 kg and >200 kg) were excluded. For the variables of fluid intake, food intake, and general physical condition, the 2 upper categories were collapsed to 1 category, because the number of participants in the highest category was small (Table 1).

In a sensitivity analysis, we included only COVID-19 cases with a record in Senior Alert within 3 months prior to the date of COVID-19. This restriction was done to examine whether results were affected by the delay between measurements in Senior Alert and the baseline date (COVID-19 test or diagnosis). All analyses were performed using Stata MP version 16.1 for Mac (StataCorp, College Station, TX). Statistical significance was determined as odds ratios with 95% CIs that did not cross 1.

Table 1
Baseline Characteristics in the Total Cohort of Residents With COVID-19 and in Matched COVID-19 Cases and Controls

Variables	All COVID-19 Cases (n = 4177)	Matched COVID-19 Cases (n = 3731)	Matched Controls (n = 3731)
Days between Senior Alert registration and baseline*, median (IQR)	119 (60-187)	120 (60-188)	120 (60-188)
Male sex	1478 (35.4)	1325 (35.5)	1318 (35.3)
Age, median (IQR), y	87 (81-92)	87 (81-92)	87 (81-92)
Age group, y			
<70	152 (3.6)	140 (3.8)	164 (4.4)
70-74	280 (6.7)	249 (6.7)	238 (6.4)
75-79	519 (12.4)	456 (12.2)	431 (11.6)
80-84	792 (19.0)	706 (18.9)	693 (18.6)
85-89	1045 (25.0)	938 (25.1)	927 (24.9)
≥90	1389 (33.3)	1242 (33.3)	1278 (34.3)
BMI, mean (SD)	25.5 (5.1)	25.4 (5.0)	25.6 (5.3)
BMI categories			
Underweight (<18.5)	265 (6.4)	240 (6.4)	258 (6.9)
Normal weight (18.5-24.99)	1865 (44.7)	1672 (44.8)	1604 (43.0)
Overweight (25.0-29.99)	1334 (32.0)	1196 (32.1)	1182 (31.7)
Obesity (≥30)	707 (17.0)	623 (16.7)	687 (18.4)
Neuropsychological conditions			
None	938 (23.7)	886 (23.8)	884 (23.7)
Mild dementia or depression	1931 (48.7)	1822 (48.8)	1805 (48.4)
Severe dementia or depression	1095 (27.6)	1023 (27.4)	1042 (27.9)
Known previous falls	2059 (52.9)	1970 (52.8)	1950 (52.3)
Walking ability			
Safe with or without walking aids	1584 (40.7)	1513 (40.6)	1492 (40.0)
Unsafe walk	1419 (36.5)	1367 (36.6)	1379 (37.0)
Unable to walk	889 (22.8)	851 (22.8)	860 (23.1)
Fluid intake, mL/d			
>1000	2315 (58.7)	2191 (58.7)	2182 (58.5)
700-1000	1402 (35.6)	1327 (35.6)	1312 (35.2)
500-700	208 (5.3)	196 (5.3)	210 (5.6)
<500	17 (0.4)	17 (0.5)	27 (0.7)
Food intake			
Normal serving	2747 (69.7)	2597 (69.6)	2.587 (69.3)
3/4 serving	720 (18.3)	686 (18.4)	699 (18.7)
½ serving	375 (9.5)	350 (9.4)	341 (9.1)
<½ serving	100 (2.5)	98 (2.6)	104 (2.8)
General physical condition			
Good	2210 (56.0)	2077 (55.7)	2034 (54.5)
Fair	1597 (40.5)	1524 (40.9)	1545 (41.4)
Poor	126 (3.2)	121 (3.2)	142 (3.8)
Very bad	9 (0.2)	9 (0.2)	10 (0.3)
Incontinence			
No	1041 (26.4)	986 (26.4)	989 (26.5)
Temporarily but unusual	602 (15.3)	565 (15.1)	556 (14.9)
Urinary or bowel	965 (24.5)	906 (24.3)	890 (23.9)
Urinary and bowel	1334 (33.8)	1274 (34.2)	1296 (34.7)
Comorbidities			
Stroke	1048 (25.1)	942 (25.3)	940 (25.2)
Myocardial infarction	500 (12.0)	446 (12.0)	431 (11.6)
Angina pectoris	643 (15.4)	576 (15.4)	574 (14.4)
Heart failure	856 (20.5)	771 (20.7)	776 (20.8)
Comorbidities			
Atrial fibrillation	1109 (26.6)	997 (26.7)	971 (26.0)
Autoimmune disease	534 (12.8)	487 (13.1)	491 (13.2)
Diabetes	928 (22.2)	825 (22.1)	845 (22.7)
COPD	539 (12.9)	483 (13.0)	486 (13.0)
Asthma	305 (7.3)	275 (7.4)	242 (6.5)
Cancer	1833 (43.9)	1687 (45.2)	1661 (44.5)
Renal failure or chronic kidney disease	566 (13.6)	521 (14.0)	536 (14.4)
Liver disease	82 (2.0)	72 (1.9)	75 (2.0)
Sepsis	350 (8.4)	316 (8.5)	309 (8.3)
Influenza	208 (5.0)	184 (4.9)	193 (5.2)
Pneumonia	1013 (24.3)	915 (24.5)	923 (24.7)
Alcohol intoxication	264 (6.3)	233 (6.2)	221 (5.9)
Medications			
Antithrombotics	2461 (58.9)	2205 (59.1)	2253 (60.4)
Antihypertensives (other than diuretics)	2494 (59.7)	2257 (60.5)	2271 (60.9)
Diuretics	1794 (43.0)	1611 (43.2)	1608 (43.1)
Antidepressants	2409 (57.7)	2178 (58.4)	2140 (57.4)
Psycholeptics	2935 (70.3)	2649 (71.0)	2648 (71.0)

COPD, chronic obstructive pulmonary disease; IQR, interquartile range; SD, standard deviation.
Data are displayed as number (percentage) unless stated otherwise.
*Baseline was the date of COVID-19 test/diagnosis in cases and a corresponding date in controls.

Results

There were 216,085 residents in LTCFs registered in Senior Alert (83,519 with a record in 2019 or 2020). Of these 216,085 residents, 5409 were confirmed with COVID-19 from 22 February 2020 to 15 September 2020. Four individuals were excluded because of missing dates of diagnosis and testing. Another 1225 residents were excluded because they did not have a record in Senior Alert within 1 year before the COVID-19 date. Three additional cases were excluded because their death date preceded their date of confirmed COVID-19. Thus, the study cohort comprised 4177 residents with COVID-19 [64.6% female, median age 87 years (interquartile range 81-97)]. Of these individuals, 3732 had complete data and 3731 could be matched to 3731 controls.

Thirty-Day Mortality and Associated Risk Factors

Baseline characteristics were similar in both unmatched and matched COVID-19 cases and controls (Table 1). Thirty-day mortality was 39.9% (n = 1487) in COVID-19 cases and 5.7% (n = 211) in controls (relative risk 7.05, 95% CI 6.10-8.14). The association of risk factors with 30-day mortality is presented in Table 2. The absolute risks by age and other risk factors are presented in Supplementary Figures 1-12.

Men had 2.5-fold higher odds of 30-day mortality than women after adjustment for other risk factors. The absolute risk of death increased with increasing age; for example, 30-day mortality was approximately 13% in 70-year-old men and 30% in 90-year-old men without other risk factors (Supplementary Figure 11). Factors related to nutrition (BMI, fluid intake, and food intake) were not associated with 30-day mortality after adjustment, although there was a trend toward increased risk from underweight. Mild and severe neuropsychological conditions (dementia or depression) were both highly prevalent and associated with higher 30-day mortality after adjustment. Compared to those with no conditions, residents with severe conditions had more than twice the odds of 30-day mortality. Neuropsychological conditions were also strongly associated with absolute risk of mortality. For example, a 90-year-old male resident with severe neuropsychological conditions had a 30-day mortality risk of almost 50%, which would have been almost 30% if he had not had neuropsychological conditions (Supplementary Figure 1). With respect to walking ability, most residents walked unsafely or were unable to walk, which was associated with higher 30-day mortality after adjustment. Compared to those in good general physical condition, residents in poorer condition had higher odds of 30-day mortality after adjustment. A third of residents had urinary and bowel incontinence, which was associated with 1.5-fold higher odds of 30-day mortality after adjustment.

Comorbidities associated with higher adjusted odds of 30-day mortality included diabetes, renal failure or chronic kidney disease, and pneumonia. Importantly, diabetes and previous pneumonia were also highly prevalent. Cancer, chronic obstructive pulmonary diseases, and antihypertensives (other than diuretics) were not associated with 30-day mortality before or after adjustment. Cardiovascular diseases, antithrombotic medication, and diuretics were only associated with higher 30-day mortality before adjustment.

Sensitivity Analysis

The sensitivity analysis comprised 1421 residents registered in Senior Alert within 3 months of confirmed COVID-19 (median 47 days, interquartile range 27-68). Of these, 566 died within 30 days (39.9%). Overall, this analysis confirmed the results of the main analysis (Supplementary Table 2).

Discussion

This study showed that 30-day mortality was 40% in Swedish LTCF residents with COVID-19, which was 7 times higher than in matched controls without COVID-19. Beyond older age and male sex, independent risk factors for higher mortality were neuropsychological conditions, impaired walking ability, incontinence, diabetes, chronic kidney disease, and previous pneumonia. These risk factors, most of which are not modifiable, were highly prevalent, and associated with a high absolute risk of death, altogether emphasizing the importance of preventing COVID-19 transmission to LTCFs.

The 40% mortality rate in our study is almost twice as high as in a US study of more than 5000 nursing home residents.[19] This difference likely reflects that our study cohort was older. Smaller studies, conducted in age groups similar to ours, showed more comparable mortality rates.[15,28,29] A limitation of all these studies is that they lacked a control group, impeding assessment of excess mortality. In this sense, our results add important evidence regarding the profound dangers of COVID-19 in LTCFs, as illustrated by the 7-fold higher mortality. Although the reason for the high mortality is likely multifactorial and complex, the disease indisputably has a tremendous significance from a public health perspective, affecting older adults, especially those living in LTCFs, disproportionally. In support, a recent study showed that LTCF residents had 4 times higher risk of COVID-19 mortality, compared with community-dwelling older adults.[30] Further, another study showed that COVID-19 is more dangerous for older adults compared to seasonal influenza, especially for older adults with certain comorbidities, being associated with a 5-fold higher risk of death.[31] Our study provides additional evidence that COVID-19 mortality is high also in older adults without other risk factors. Altogether, the findings from our study suggest that COVID-19 has caused a large number of premature deaths in Swedish LTCFs.

In our study, older age, male sex, and neuropsychological conditions were among the most important risk factors for 30-day mortality in LTCF residents with COVID-19. Although these risk factors are known from previous studies,[15,16,19,29] less is known about their additive effects. Therefore, we also examined how the absolute risk of death varied depending on these 3 risk factors. For example, a 90-year-old male resident with severe neuropsychological conditions had a 30-day mortality risk of around 50%, which would have been 30% if he had not had neuropsychological conditions. In women, the corresponding difference was around 25% vs 15%. These large absolute differences strengthen the clinical importance of these 3 risk factors, and pinpoints groups that are especially critical to protect against being infected in LTCFs.

Two other common patient characteristics that were associated with higher mortality were impaired walking ability and urine and bowel incontinence. Previous studies found physical function and frailty to be risk factors for 30-day mortality after COVID-19 in LTCFs[15,19] and in-hospital mortality in older adults.[32] In one study, bowel incontinence was a risk factor for COVID-19 diagnosis.[17] Thus, our study shows that in a large cohort of LTCF residents, easy-to-assess characteristics such as walking ability and incontinence are prevalent and independent risk factors for mortality after COVID-19.

In contrast, no association was found between obesity and mortality. Although obesity is a well-known risk factor for developing severe COVID-19 in the general population,[14] studies in older people have shown conflicting results.[33,34] The lack of association in our study may be related to the well-known obesity paradox in very old people,[35] for whom body-mass-index is a poor indicator of body composition and body fat distribution.[36] It has also been hypothesized that malnutrition could be an important risk factor,[37,38] but we did not find an association between food intake and mortality after adjustment for other risk factors, as in a previous study.[18] However, there was a trend toward an increased risk of mortality in those with the

Table 2
Risk Factors for All-Cause 30-Day Mortality in Residents With COVID-19

Variables	n	Number of Deaths (%)	Unadjusted OR (95% CI)	Adjusted* OR (95% CI)
Male sex	1478	747 (50.5)	2.04 (1.79, 2.33)	2.60 (2.22, 3.05)
Age group, y				
<70	152	34 (22.4)	1 (ref)	1 (ref)
70-74	280	88 (31.4)	1.59 (1.01, 2.51)	1.45 (0.89, 2.39)
75-79	519	167 (32.2)	1.65 (1.08, 2.52)	1.50 (0.95, 2.38)
80-84	792	321 (40.5)	2.37 (1.57, 3.55)	2.44 (1.57, 3.81)
85-89	1045	449 (43.0)	2.62 (1.75, 3.90)	2.99 (1.93, 4.65)
≥90	1389	588 (42.3)	2.55 (1.72, 3.79)	3.28 (2.11, 5.10)
BMI categories				
Underweight (<18.5)	265	120 (45.3)	1.28 (0.99, 1.66)	1.31 (0.98, 1.77)
Normal weight (18.5-24.99)	1865	733 (39.3)	1 (ref)	1 (ref)
Overweight (25.0-29.99)	1334	520 (39.0)	0.99 (0.84, 1.14)	1.03 (0.87, 1.22)
Obesity (≥30)	707	272 (38.5)	0.96 (0.81, 1.15)	1.16 (0.94, 1.44)
Neuropsychological conditions				
None	938	305 (32.5)	1 (ref)	1 (ref)
Mild dementia or depression	1931	744 (38.5)	1.30 (1.10, 1.53)	1.47 (1.22, 1.77)
Severe dementia or depression	1095	525 (48.0)	1.91 (1.60, 2.29)	2.18 (1.76, 2.71)
Known previous falls	2059	868 (42.2)	1.24 (1.09, 1.41)	1.07 (0.92, 1.24)
Walking ability				
Safe with or without walking aids	1584	498 (31.4)	1 (ref)	1 (ref)
Unsafe walk	1419	631 (44.5)	1.75 (1.50, 2.03)	1.30 (1.09, 1.55)
Unable to walk	889	417 (46.9)	1.93 (1.63, 2.28)	1.45 (1.17, 1.78)
Fluid intake, mL/d				
>1000	2315	900 (38.9)	1 (ref)	1 (ref)
700-1000	1402	557 (39.7)	1.04 (0.91, 1.19)	0.94 (0.80, 1.09)
<700	225	105 (46.7)	1.38 (1.05, 1.81)	1.09 (0.79, 1.51)
Food intake				
Normal serving	2747	1049 (38.2)	1 (ref)	1 (ref)
¾ serving	720	307 (42.6)	1.20 (1.02, 1.42)	1.15 (0.95, 1.39)
≤½ serving	475	206 (43.4)	1.24 (1.02, 1.51)	1.13 (0.89, 1.44)
General physical condition				
Good	2210	788 (35.7)	1 (ref)	1 (ref)
Fair	1597	703 (44.0)	1.42 (1.24, 1.62)	1.20 (1.04, 1.40)
Poor or very bad	135	71 (52.6)	2.00 (1.41, 2.84)	1.41 (0.95, 2.08)
Incontinence				
No	1041	319 (30.6)	1 (ref)	1 (ref)
Temporarily but unusual	602	207 (34.4)	1.19 (0.96, 1.47)	1.00 (0.79, 1.27)
Urinary or bowel	965	401 (41.6)	1.61 (1.34, 1.94)	1.23 (1.00, 1.52)
Urinary and bowel	1334	635 (47.6)	2.06 (1.74, 2.44)	1.51 (1.22, 1.86)
Comorbidities				
Stroke	1048	441 (42.1)	1.16 (1.01, 1.34)	1.02 (0.86, 1.21)
Myocardial infarction	500	220 (44.0)	1.24 (1.03, 1.50)	0.93 (0.74, 1.18)
Angina pectoris	643	278 (43.2)	1.21 (1.02, 1.43)	1.12 (0.91, 1.38)
Heart failure	856	366 (42.8)	1.19 (1.02, 1.39)	0.95 (0.78, 1.17)
Atrial fibrillation	1109	468 (42.2)	1.17 (1.02, 1.35)	0.94 (0.78, 1.13)
Autoimmune disease	534	231 (43.3)	1.20 (1.00, 1.44)	1.19 (0.97, 1.47)
Diabetes	928	428 (46.1)	1.43 (1.23, 1.65)	1.36 (1.14, 1.62)
COPD	539	221 (41.0)	1.08 (0.90, 1.30)	1.01 (0.81, 1.27)
Asthma	305	109 (35.7)	0.84 (0.66, 1.08)	0.79 (0.59, 1.05)
Cancer	1833	736 (40.2)	1.06 (0.93, 1.20)	0.91 (0.78, 1.05)
Renal failure or chronic kidney disease	566	273 (48.2)	1.52 (1.27, 1.81)	1.37 (1.11, 1.68)
Liver disease	82	30 (36.6)	0.88 (0.56, 1.39)	0.88 (0.52, 1.50)
Comorbidities				
Sepsis	350	147 (42.0)	1.12 (0.90, 1.40)	0.80 (0.62, 1.04)
Influenza	208	90 (43.3)	1.18 (0.89, 1.57)	0.98 (0.71, 1.36)
Pneumonia	1013	493 (48.7)	1.65 (1.43, 1.91)	1.57 (1.32, 1.86)
Alcohol intoxication	264	86 (32.6)	0.73 (0.56, 0.95)	0.73 (0.53, 1.00)
Medications				
Antithrombotics	2461	1013 (41.2)	1.19 (1.05, 1.36)	1.04 (0.88, 1.23)
Antihypertensives (other than diuretics)	2494	1003 (40.2)	1.09 (0.96, 1.23)	1.01 (0.87, 1.18)
Diuretics	1794	761 (42.4)	1.25 (1.10, 1.41)	1.14 (0.97, 1.34)
Antidepressants	2409	979 (40.6)	1.13 (0.99, 1.28)	1.10 (0.95, 1.28)
Psycholeptics	2935	1172 (39.9)	1.07 (0.94, 1.23)	1.03 (0.88, 1.21)

COPD, chronic obstructive pulmonary disease.
*Adjusted for all variables in column 1 and days since Senior Alert registration. The analysis included n = 3732 participants and 1488 cases of death.

lowest BMI. Although this did not reach statistical significance, likely because of the small number of people in that BMI category, it cannot be ruled out that underweight is a risk factor for COVID-19 mortality in LTCF residents.

Having diabetes or renal failure or chronic kidney disease was both common and associated with increased risk of 30-day mortality. Both these conditions have previously been identified as risk factors for mortality following COVID-19 in LTCF residents.[19] Also, history of pneumonia was common and a strong risk factor for 30-day mortality. Although we are not aware of any other studies that have investigated pneumonia as a risk factor in LTCF residents, it was recently shown that previous pneumonia is a risk factor for COVID-19 diagnosis,

hospitalization, and subsequent all-cause mortality in the general Swedish population.[39] Hypothetically, previous pneumonia could be a marker of impaired immune function that increases one's susceptibility for severe COVID-19 infection.

In our study, antihypertensives were not associated with mortality after COVID-19. This extends the results of observational studies showing that hypertension is not a risk factor in LTCF residents[19,29] and is supported by randomized studies showing that continuation of antihypertensive treatment did not increase the risk of severe outcomes, as compared to discontinuation, in patients hospitalized with COVID-19.[40,41] Similarly, many other common diseases or medications were not associated with mortality in this study, including cardiovascular disease, antithrombotics, pulmonary disease, and cancer. An explanation for these findings could be that many prevalent diagnoses have little impact on mortality risk in very frail older people who have lived to an old age. It should also be noted that because different conditions are likely less often diagnosed in LTCFs, and primary care diagnoses care are not captured in the NPR, the sensitivity to capture different diagnoses is likely lower than in community-dwelling individuals. Regardless, our results are similar to previous studies of nursing home residents,[15,19,29] geriatric patients,[32] and veterans.[42]

This study has several important strengths. To our knowledge, this is the first study to evaluate 30-day mortality following COVID-19 in LTCFs using a control group. The study cohort included a large representative population of LTCF residents from the whole of Sweden, who are of particular importance to study given that they have experienced the highest mortality rates from COVID-19. Moreover, more than 30 potential risk factors and clinical patient characteristics were available, and these were investigated through a comprehensive set of analyses, increasing the credibility of our findings. Some limitations of this study should also be considered. First, the data obtained from Senior Alert may not be completely accurate for the time of COVID-19 infection owing to the lag time between assessment in Senior Alert and baseline (COVID-19), although a sensitivity analysis suggested that this did not bias associations. Second, because the study cohort was restricted to residents in LTCFs with a record in Senior Alert in the past year, generalizability to all LTCF residents in Sweden may in theory be limited. However, our data captured 5409 cases compared to the 7143 cases confirmed in LTCFs in Sweden until mid-September according to official data,[43] meaning that the coverage in our study was high. Third, the accuracy regarding identification of certain risk factors may be limited. For example, neuropsychological conditions comprised both dementia and depression, although these are clearly different conditions. Yet, using this item, we observed an OR of similar magnitude to that shown in a previous study where cognitive function was assessed using the Minimum Data Set.[19] Moreover, although we had access to a wide array of potential risk factors, we lacked data on symptoms at COVID-19 presentation, which have previously been associated with mortality following COVID-19 in LTCF residents.[19] Fifth, data on LTCF characteristics were lacking, for example data on staffing and structure, which could have influenced the transmission and mortality of COVID-19. Sixth, the results are not necessarily generalizable to other countries. Finally, although COVID-19 cases and controls were matched, there may be unmeasured differences between the groups that may partly have contributed to the higher mortality in cases.

Conclusions and Implications

In summary, 30-day mortality was 7 times higher in Swedish LTCF residents with COVID-19 than in matched controls, suggesting that the excess mortality is due to the COVID-19 infection itself and not older age or poorer health status. In addition, beyond older age and male sex, some diagnoses and simple measures of health status predict short-term mortality. Because large-scale community transmission has been deemed one of the primary explanations for the high COVID-19 mortality rates in Swedish LTCFs,[8] our findings emphasize that reducing transmission of COVID-19 to LTCFs, would likely prevent a considerable number of deaths in this frail group of older individuals.

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Supplementary Material 1

Measures taken by Swedish authorities during the first wave of the COVID-19 pandemic.

An in-depth review of Sweden's COVID-19 strategy, including a detailed timeline of key events and adopted measures, during the first wave of the pandemic is available from Ludvigsson JF. The first eight months of Sweden's COVID-19 strategy and the key actions and actors that were involved. Acta Paediatr 2020; 109:2459–2471. Available at: https://onlinelibrary.wiley.com/doi/10.1111/apa.15582.

Supplementary Table 1
Definitions of Comorbidities and Prescription Medications

Variable	Definition	Code Type	Codes
Comorbidities			
Myocardial infarction	Myocardial infarction	*ICD-9/10-SE*	I21, I22, 410
Stroke	Stroke	*ICD-9/10-SE*	I60-I64, 431-434
Angina pectoris	Angina pectoris	*ICD-9/10-SE*	I20, 413
Heart failure	Heart failure	*ICD-9/10-SE*	I50, 428
Atrial fibrillation	Atrial fibrillation	*ICD-9/10-SE*	I48, 427D
Autoimmune disease	Rheumatoid arthritis	*ICD-9/10-SE*	M05, M06, 714
	Inflammatory bowel disease	*ICD-9/10-SE*	K50-K52, 555
	Multiple sclerosis	ICD-10-SE	G35
	Autoimmune hepatitis	ICD-10-SE	K754
	Systemic lupus erythematosus	*ICD-9/10-SE*	M32, 710A
	Psoriatic arthritis	ICD-10-SE	L405, M073
	Ankylosing spondylitis	*ICD-9/10-SE*	M45, 720A
	Giant cell arteritis	*ICD-9/10-SE*	M315, M316, 446F
	Polymyalgia rheumatica	*ICD-9/10-SE*	M353, 725
	Sjögren/sicca syndrome	*ICD-9/10-SE*	M350, 710C
	Systemic sclerosis	*ICD-9/10-SE*	M34, 710B
Diabetes	Diabetes	*ICD-9/10-SE*	E10, E11, 250
	Antidiabetic agent	ATC	A10
Cancer	Malignant neoplasms	ICD-10-SE	C
	Malignant neoplasms	ICD-7-SE*	140-209*
Chronic obstructive pulmonary disease	Chronic obstructive pulmonary disease	*ICD-9/10-SE*	J20, J40-J44, 491, 492
Asthma	Asthma	*ICD-9/10-SE*	J45, J46, 493
Renal failure or chronic kidney disease	Renal failure or chronic kidney disease	*ICD-9/10-SE*	N17-N19, 584-586
Liver disease	Liver disease	ICD-10-SE	K70-K77
Sepsis	Sepsis	ICD-10-SE	A40, A41
Influenza	Influenza	ICD-10-SE	J09-J11
Pneumonia	Pneumonia	ICD-10-SE	J12-J18
Alcohol intoxication	Alcohol intoxication	*ICD-9/10-SE*	F10, 291, 303
Prescription medications			
Antithrombotics	Antithrombotics	ATC	B01A
Antihypertensives† (other than diuretics)	Angiotensin-converting enzyme inhibitors/angiotensin II receptor blocker	ATC	C09
	Calcium-receptor blocker	ATC	C08
Diuretic†	Diuretic	ATC	C03
Antidepressants†	Antidepressants	ATC	N06A
Psycholeptics†	Psycholeptics	ATC	N05

ATC, anatomical therapeutic chemical; *ICD-9/10-SE, International Classification of Diseases, 9th/10th Revision, Swedish Version.*

*Obtained from the Swedish Cancer Registry from 1964-2018.

†Information regarding use of these medications were additionally obtained from the Senior Alert assessment. Thus, use of these medications were defined as either a prescription in the Prescribed Drug Register or as use reported in Senior Alert.

Supplementary Table 2
Risk Factors for All-Cause 30-Day Mortality in the Sensitivity Analysis Including Residents With COVID-19 Who Were Registered in Senior Alert Within 3 Months of COVID-19 Diagnosis

Variables	Adjusted* OR (95% CI)
Male sex	2.67 (2.06, 3.46)
Age group	
<70	1 (ref)
70-74	1.45 (0.68, 3.11)
75-79	1.11 (0.55, 2.27)
80-84	1.53 (0.77, 3.06)
85-89	1.99 (1.00, 3.93)
≥90	2.51 (1.27, 4.98)
BMI categories	
Underweight (<18.5)	1.11 (0.67, 1.83)
Normal weight (18.5-24.99)	1 (ref)
Overweight (25.0-29.99)	1.41 (1.08, 1.84)
Obesity (≥30)	1.21 (0.83, 1.77)
Neuropsychological conditions	
None	1 (ref)
Mild dementia or depression	1.12 (0.83, 1.52)
Severe dementia or depression	1.84 (1.28, 2.64)
Known previous falls	1.27 (0.99, 1.62)
Walking ability	
Safe with or without walking aids	1 (ref)
Unsafe walk	1.45 (1.08, 1.95)
Unable to walk	1.78 (1.26, 2.49)
Fluid intake, mL/d	
>1000	1 (ref)
700-1000	0.96 (0.74, 1.24)
<700	0.74 (0.43, 1.28)
Food intake	
Normal serving	1 (ref)
¾ serving	0.94 (0.70, 1.28)
≤½ serving	1.12 (0.76, 1.64)
General physical condition	
Good	1 (ref)
Fair	1.44 (1.12, 1.85)
Poor or very bad	1.48 (0.74, 2.96)
Incontinence	
No	1 (ref)
Temporarily but unusual	0.93 (0.62, 1.40)
Urinary or bowel	1.18 (0.84, 1.66)
Urinary and bowel	1.47 (1.04, 2.07)
Comorbidities	
Stroke	0.95 (0.71, 1.25)
Myocardial infarction	0.87 (0.60, 1.27)
Angina pectoris	1.00 (0.70, 1.42)
Heart failure	1.02 (0.73, 1.42)
Atrial fibrillation	0.88 (0.65, 1.19)
Autoimmune disease	1.12 (0.79, 1.58)
Diabetes	1.31 (0.98, 1.74)
COPD	0.73 (0.50, 1.06)
Asthma	0.80 (0.50, 1.29)
Cancer	0.87 (0.69, 1.11)
Comorbidities	
Renal failure or chronic kidney disease	1.12 (0.79, 1.60)
Liver disease	1.08 (0.44, 2.66)
Sepsis	0.66 (0.42, 1.03)
Influenza	0.70 (0.39, 1.23)
Pneumonia	1.79 (1.35, 2.38)
Alcohol intoxication	0.58 (0.35, 0.98)
Medications	
Antithrombotics	1.21 (0.92, 1.58)
Antihypertensives (other than diuretics)	1.10 (0.85, 1.43)
Diuretics	0.84 (0.64, 1.09)
Antidepressants	1.16 (0.90, 1.48)
Psycholeptics	1.15 (0.87, 1.51)

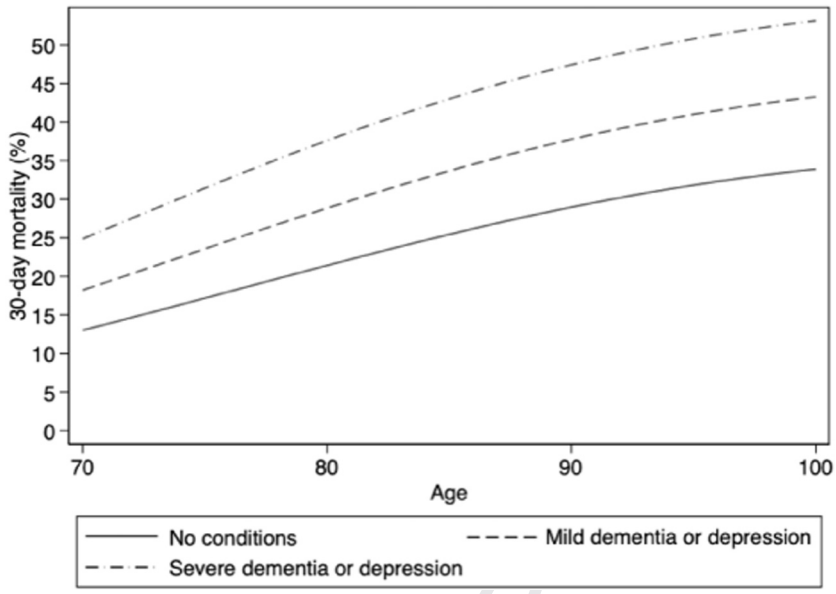
CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio.

*Adjusted for all variables in column 1. The analysis included N = 1421 participants and 566 cases of death.

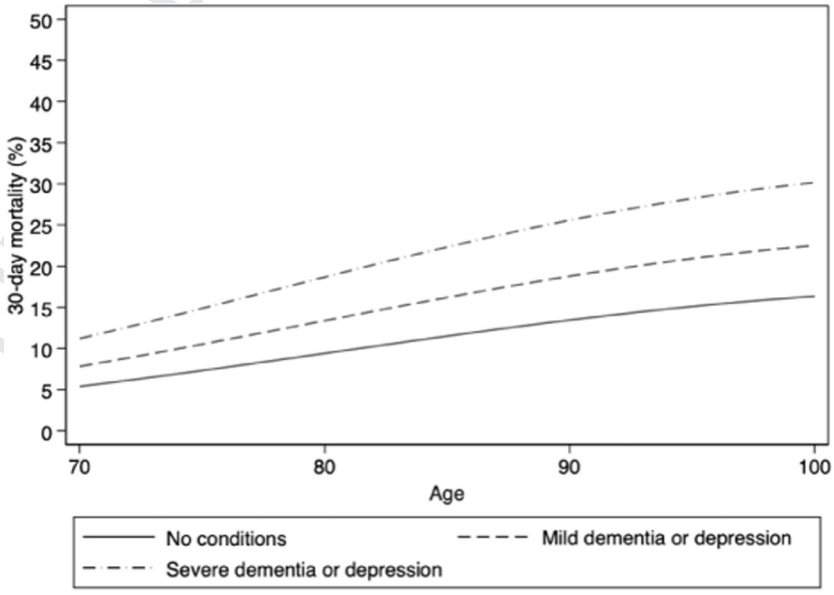
Supplementary Table 3
Amount of Missing Data in Residents With COVID-19

Variables	Missing Data in the Total COVID-19 Cohort (n = 4177)	Missing Data Among Those Who Died Within 30 d (n = 1647)	Missing Data Among Those Alive at 30 d (n = 2530)
Sex	0	0	0
Age	0	0	0
BMI	6	2	4
Neuropsychological conditions	213	73	140
Known previous falls	285	101	184
Walking ability	285	101	184
Fluid intake, mL/d	235	85	150
Food intake	235	85	150
General physical condition	235	85	150
Incontinence	235	85	150
Comorbidities			
Stroke	0	0	0
Myocardial infarction	0	0	0
Angina pectoris	0	0	0
Heart failure	0	0	0
Atrial fibrillation	0	0	0
Autoimmune disease	0	0	0
Diabetes	0	0	0
COPD	0	0	0
Asthma	0	0	0
Cancer	0	0	0
Renal failure or chronic kidney disease	0	0	0
Liver disease	0	0	0
Sepsis	0	0	0
Influenza	0	0	0
Pneumonia	0	0	0
Alcohol intoxication	0	0	0
Medications			
Antithrombotics	0	0	0
Antihypertensives (other than diuretics)	0	0	0
Diuretics	0	0	0
Antidepressants	0	0	0
Psycholeptics	0	0	0

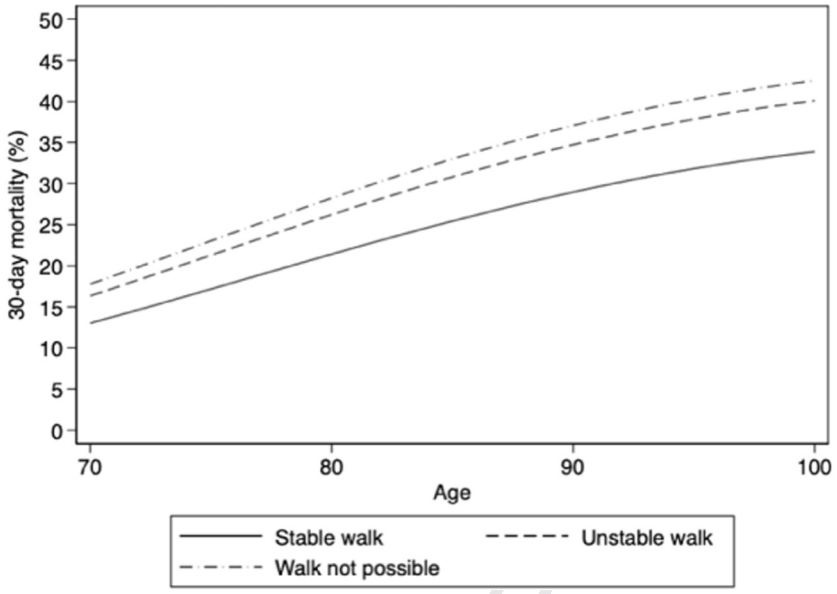
BMI, body mass index; COPD, chronic obstructive pulmonary disease.



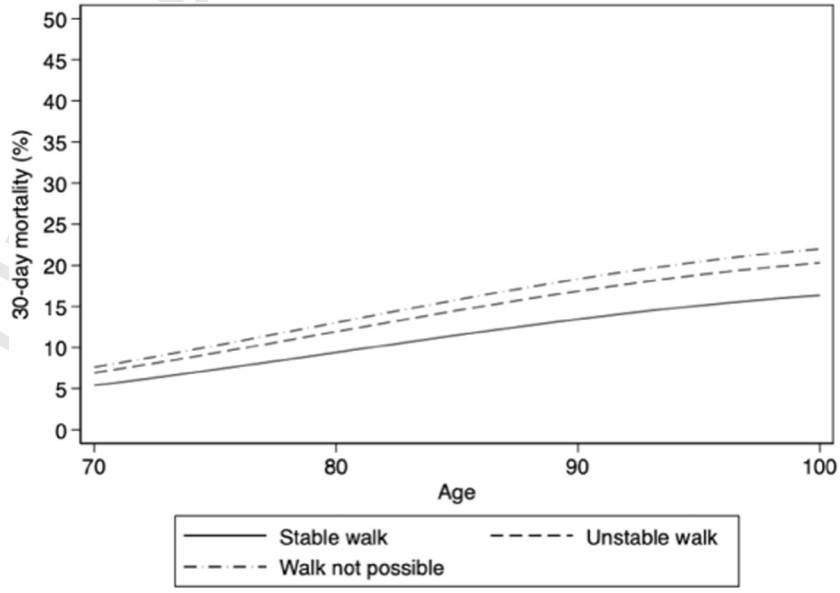
Supplementary Fig. 1. Neuropsychological conditions and absolute risk of 30-day mortality in men without other risk factors.



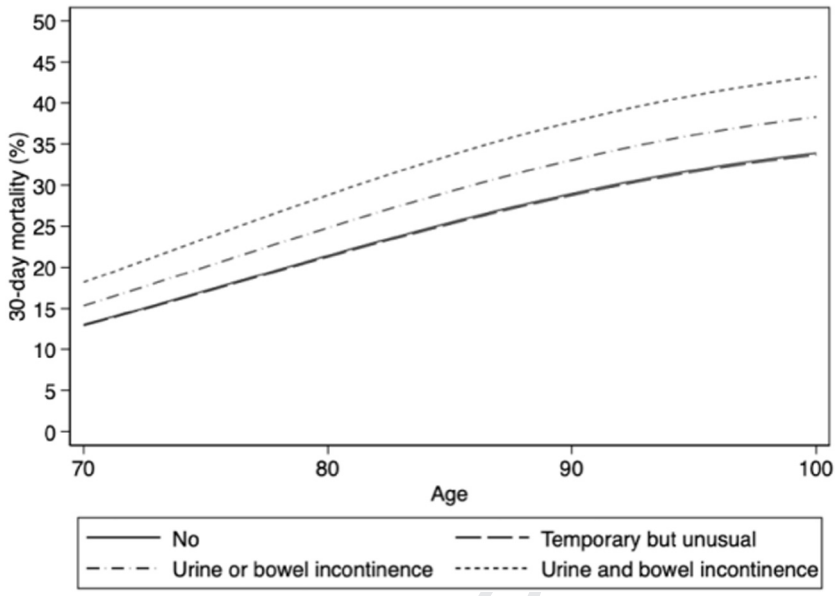
Supplementary Fig. 2. Neuropsychological conditions and absolute risk of 30-day mortality in women without other risk factors.



Supplementary Fig. 3. Walking ability and absolute risk of 30-day mortality in men without other risk factors.

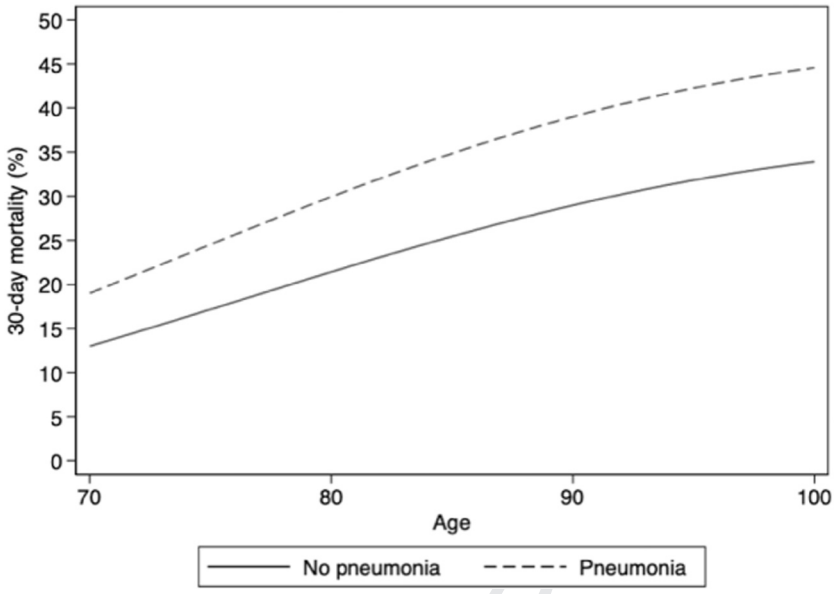


Supplementary Fig. 4. Walking ability and absolute risk of 30-day mortality in women without other risk factors.

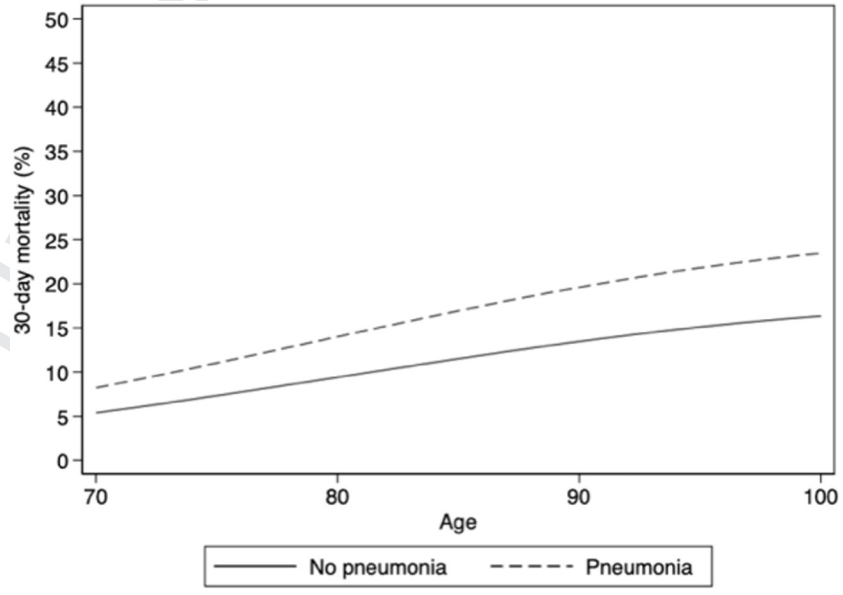


Supplementary Fig. 5. Incontinence and absolute risk of 30-day mortality in men without other risk factors.

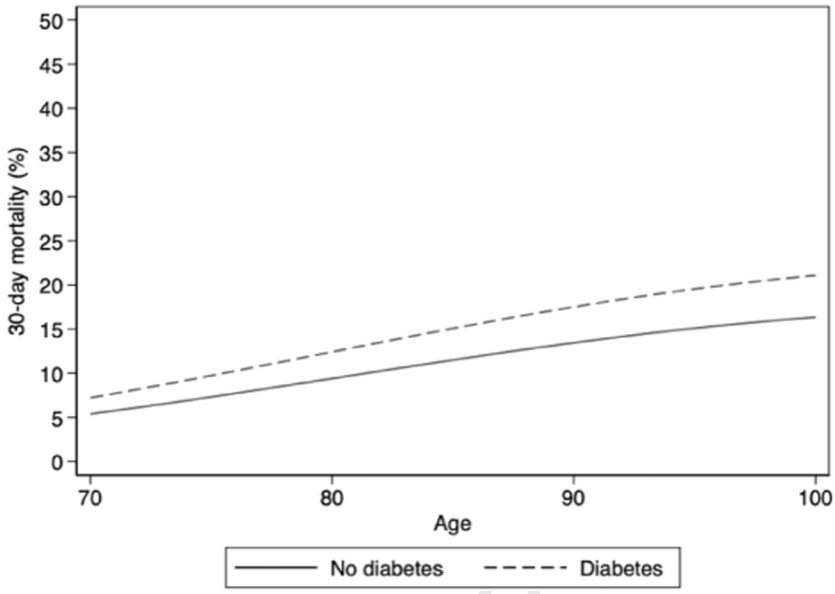
Supplementary Fig. 6. Incontinence and absolute risk of 30-day mortality in women without other risk factors.



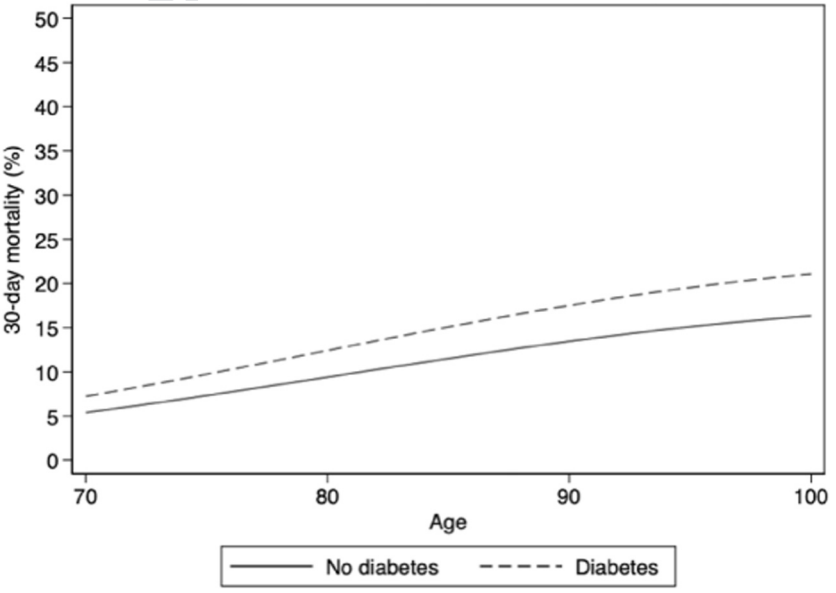
Supplementary Fig. 7. Pneumonia and absolute risk of 30-day mortality in men without other risk factors.



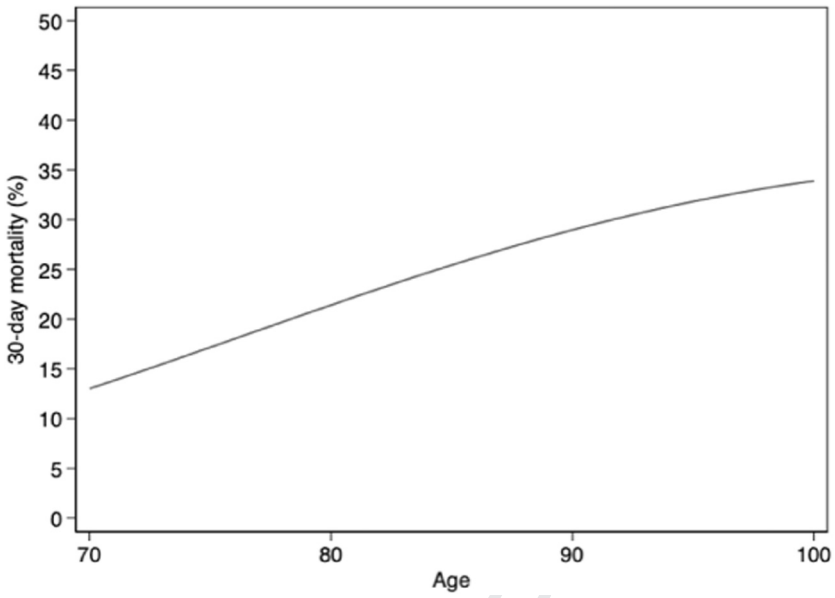
Supplementary Fig. 8. Pneumonia and absolute risk of 30-day mortality in women without other risk factors.



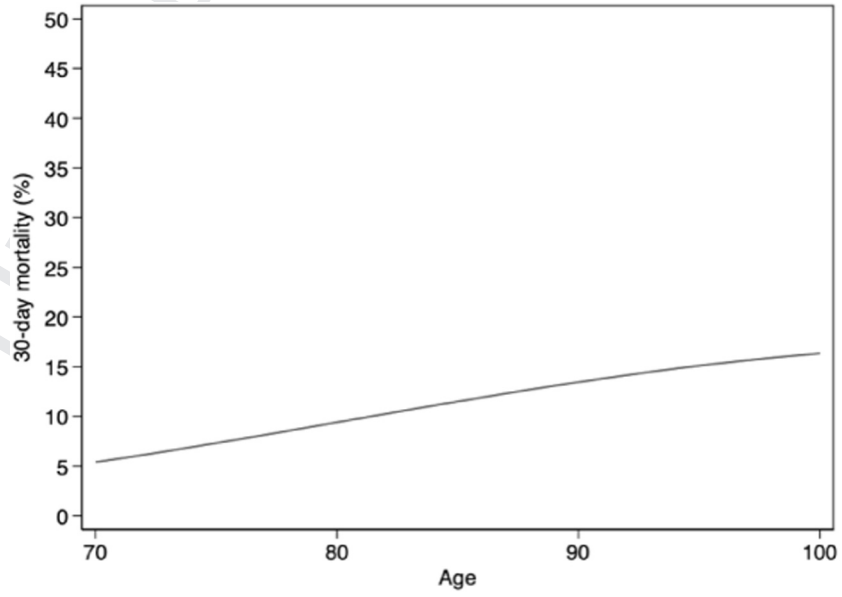
Supplementary Fig. 9. Diabetes and absolute risk of 30-day mortality in men without other risk factors.



Supplementary Fig. 10. Diabetes and absolute risk of 30-day mortality in women without other risk factors.



Supplementary Fig. 11. Age and absolute risk of 30-day mortality in men without other risk factors.



Supplementary Fig. 12. Age and absolute risk of 30-day mortality in women without other risk factors.