Deaths involving COVID-19 by self-reported disability status during the first two waves of the COVID-19 pandemic in England: a retrospective, population-based cohort study

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Summary

Background People with learning disabilities are at substantially increased risk of COVID-19 mortality, but evidence on risks of COVID-19 mortality for disabled people more generally is limited. We aimed to use population-level data to estimate the association between self-reported disability and death involving COVID-19 during the first two waves of the COVID-19 pandemic in England.

Methods We conducted a retrospective, population-based cohort study of adults aged 30–100 years living in private households or communal establishments in England, using data from the Office for National Statistics Public Health Data Asset. Participants were present at the 2011 Census and alive on Jan 24, 2020. Participants reported being limited a lot in their daily activities, limited a little, or not limited at all, in response to a question from the 2011 Census. The outcome was death involving COVID-19, occurring between Jan 24, 2020, and Feb 28, 2021. We used Cox proportional hazards regression to calculate hazard ratios (HRs) for the association between disability and death involving COVID-19, sequentially adjusting for age, residence type (private household, care home, or other communal establishment), geographical characteristics (local authority district and population density), sociodemographic characteristics (ethnicity, highest qualification, Index of Multiple Deprivation decile, household characteristics [National Statistics Socio-economic Classification of the household reference person, tenure of household, household size, family status, household composition, and key worker in household], key worker type, individual and household exposure to disease, and individual and household proximity to others), and health status (pre-existing health conditions, body-mass index, and number of admissions to hospital and days spent in hospital over the previous 3 years).

Findings 29 293 845 adults were included in the study (13 806 623 [47%] men, 15 487 222 [53%] women), of whom 3 038 772 (10%) reported being limited a little and 2 011 576 (7%) reported being limited a lot. During follow-up, 105 213 people died from causes involving COVID-19 in England, 61 416 (58%) of whom were disabled. Age-adjusted analyses showed higher mortality involving COVID-19 among disabled people who were limited a lot (HR 3·05 [95% CI 2·98–3·11] for men; 3·48 [3·41–3·56] for women) and disabled people who were limited a little (HR 1·88 [1·84–1·92] for men; 2·03 [1·98–2·08] for women) than among non-disabled people. Adjustment for residence type, geography, sociodemographics, and health conditions reduced but did not eliminate the associations between disability and death involving COVID-19 (HR 1·35 [1·32–1·38] for men who were limited a lot; 1·21 [1·18–1·23] for men who were limited a little; 1·55 [1·51–1·59] for women who were limited a lot; and 1·28 [1·25–1·31] for women who were limited a little).

Interpretation Given the association between disability and mortality involving COVID-19, verification of these findings and consideration of recommendations for protective measures are now required.

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Introduction

COVID-19 had caused at least 4·7 million deaths globally by Sept 23, 2021, including almost 136 000 in the UK.[1] Identifying groups of people at high risk, such as people with learning disabilities,[2–7] is crucial to target pandemic responses, including vaccine prioritisation. However, although there are at least 1 billion disabled people globally,[8] including 11·5 million in England,[9] evidence regarding the risk of COVID-19 mortality among disabled people is limited. One exception is a nationwide study in South Korea, which showed that people with moderate or severe disability were six times more likely than non-disabled people to die from COVID-19,[10] and were at higher risk of SARS-CoV-2 infection and major adverse clinical outcomes.[11]

Despite limited evidence, there is a strong rationale for an association between disability and COVID-19 mortality. First, disabled people are on average older

Research in context

Evidence before this study

We searched PubMed for articles published in English up to June 22, 2021, using the following search terms: "COVID" or "coronavirus" AND "disab*" AND "mortality" OR "death". Of 191 results, only one small study from South Korea compared COVID-19 mortality between disabled people and non-disabled people. This study showed a strong excess mortality risk associated with disability. Eight further studies were identified (one of which covered two topics), which showed an excess mortality risk associated with categories of disability, including learning disabilities (five studies), neurological conditions (three studies), and frailty (one study).

Added value of this study

In this retrospective, population-based cohort study we showed that rates of death involving COVID-19 were higher for disabled people than for non-disabled people in England during the first two waves of the COVID-19 pandemic. Relative risks were particularly high among younger disabled people, disabled women, and people with greater levels of activity limitation. A combination of adverse socioeconomic, demographic, and health-related risk factors accounted for some of the elevated risk among disabled people.

Implications of all the available evidence

People with learning disabilities have already been identified as a priority group for the COVID-19 response. This study shows that consideration should be given to disabled people more generally in the COVID-19 response, including in data analysis and implementation of protective measures (eg, accessible messaging and services, and criteria for vaccine prioritisation).

than non-disabled people,[8,9] and older people have an increased risk of COVID-19 mortality. Second, disabled people might be clinically vulnerable as they are more likely than non-disabled people to have known risk factors for severe COVID-19 (eg, obesity and diabetes),[12,13] and health conditions underlying disability might confer increased risk (eg, Down syndrome or Parkinson's disease).[3,4] Third, disabled people might be at increased risk of SARS-CoV-2 infection as a result of contact with carers, residence in care homes, or scarcity of accessible information on protective measures.[9,14] Fourth, outcomes might be worse in disabled people than in non-disabled people if they experience poor quality of treatment or barriers to accessing care.[15] Last, disabled people are more likely than non-disabled people to experience poverty and deprivation,[8,9] which are associated with increased risk of COVID-19-related death.[13]

Regardless of the mechanism, if disabled people are at increased risk of death from COVID-19, they will require additional focus in pandemic control efforts. People with learning disabilities, care-home residents, and people considered clinically extremely vulnerable are now prioritised for COVID-19 vaccination in the UK[6,16] and other high-income settings.[17] However, other disabled people are not prioritised explicitly in the pandemic response in the UK or elsewhere.[18]

See Online for appendix

In this study, we used population-level data from England to estimate the association between self-reported disability and death involving COVID-19, building on previous reports that showed an excess risk of death linked to COVID-19 among people reporting disability in the 2011 Census.[19,20] These new analyses include more up-to-date data and explore the nature of any associations in more detail. We also explored whether the risk varied between the first and second waves of the pandemic, and the likely reasons for any associations.

Methods

Study design and participants

We conducted a retrospective, population-based cohort study of adults aged 30–100 years living in private households or communal establishments (including care homes) in England, using data from the Office for National Statistics Public Health Data Asset. The Public Health Data Asset comprises linked data from the 2011 Census, General Practice Extraction Service (GPES) Data for Pandemic Planning and Research (GDPPR), Hospital Episode Statistics Admitted Patient Care data, and death registrations. The GDPPR dataset contains primary care records for 56·4 million National Health Service (NHS) patients with active current registrations at participating practices at the start of the pandemic, representing 99·8% of the official mid-2020 population estimate for England. Hence, the study population includes people enumerated at the 2011 Census who were alive on Jan 24, 2020, and could be linked to the 2011–13 NHS Patient Register and GDPPR dataset. We excluded individuals younger than 30 years in 2020, as their living circumstances are likely to have changed since 2011. Overall, the study population included 81% of the 2020 population aged 30 and older in England (appendix p 1). Ethical approval was obtained from the National Statistician's Data Ethics Advisory Committee (NSDEC(20)12).

Exposure, covariates, and outcomes

The exposure was self-reported disability status, retrieved from the 2011 Census question: "Are your day-to-day activities limited because of a health problem or disability which has lasted, or is expected to last, at least 12 months? Include problems related to old age". The response options were "Yes, limited a lot" (which we classified as disabled—limited a lot), "Yes, limited a little" (classified as disabled—limited a little) and "No" (classified as non-disabled).

The following covariates were included from the 2011 Census data: age, residence type (private household, care home, or other communal establishment), household tenure, National Statistics Socio-economic Classification of household reference person (defined in accordance with UK Government Statistical Service harmonised definitions[21]), highest qualification, ethnicity, household size, family status (not in a family, in a couple, or in a lone-parent family), household composition, key worker in household, and key worker type. Body-mass index (BMI), chronic kidney disease, cancer, immunosuppression, and other health conditions (from the QCOVID risk prediction model)[22] were included as covariates from the GPES data (Jan 1, 2015, to Dec 31, 2019). The number of admissions to, and number of days spent in, admitted patient care were included as covariates from the Hospital Episode Statistics Admitted Patient Care data (April 1, 2017, to Dec 31, 2019). The following covariates were included from other data sources: local authority district (from the National Statistics Postcode Lookup), population density of the Lower layer Super Output Area (from mid-2019 population estimates), and Index of Multiple Deprivation (from the English Indices of Deprivation, 2019) derived from postcodes from GPES data; individual and household exposure to disease and proximity to others (from the Occupational Information Network database based on 2011 Census data on occupation;[23] more information in the appendix p 13); and care-home residence status (from the 2019 NHS Patient Register).

The outcome was death involving COVID-19 (ie, COVID-19 International Classification of Diseases 10 code of U07.1 or U07.2 in part I or II of the death certificate), occurring between Jan 24, 2020 (when the first case of COVID-19 was reported in the UK[22]) and Feb 28, 2021. This definition includes deaths for which COVID-19 might not have been the underlying (main) cause of death but was a contributory factor, as opposed to deaths due to COVID-19, for which COVID-19 was recorded as the underlying cause of death.

Statistical analysis

The study population characteristics included in the modelling were compared across disability groups using standardised differences (*d*).

We calculated age-standardised mortality by disability status as deaths per 100 000 person-years at risk to examine the absolute risk of death involving COVID-19, standardised to the 2013 European Standardised Population.[24]

We estimated the cumulative incidence of death involving COVID-19 using the Aalen-Johansen estimator to account for the competing risk of death not involving COVID-19. Analyses were adjusted for confounding by age using inverse probability weighting with stabilised weights.

As the pandemic was ongoing at the end of the study period, the data were subject to right-censoring. We therefore used Cox proportional hazards models to assess whether differences in the risk of mortality involving COVID-19 by disability status could be accounted for by covariates. The index date for survival times was Jan 24, 2020. We included all individuals who died of any cause during the analysis period (n=527 378) and a random sample (selected by simple random sampling without replacement) of those who did not, with sampling rates of 5% (n=288 899) for disabled people and 1% (n=238 479) for non-disabled people; case weights equal to the inverse probability of selection were included in the analysis.

We introduced potential explanatory factors (both confounders and mediators) sequentially. Model 1 included adjustment for single year of age, included as a second-order polynomial. Model 2 included additional adjustment for type of residence (private household, care home, or other communal establishment). In model 3, we included additional adjustment for geographical (local authority district and local population density) and socioeconomic and demographic factors (ethnicity, highest qualification, Index of Multiple Deprivation decile, household characteristics [National Socio-economic Classification of the household reference person, tenure of the household, household size, family status, household composition, and key worker in the household], key worker type, individual and household exposure to disease, and individual and household proximity to others). In model 4, additional adjustment was made for health status (pre-existing health conditions, BMI, and number of admissions to hospital and days spent in hospital over the previous 3 years). All health variables were interacted with a binary indicator, allowing the effects to vary depending on whether the individual was aged 70 years and older or younger than 70 years.

We stratified analyses by sex as it was a highly significant effect modifier ($p<0\cdot0001$). Post-hoc subgroup analyses were conducted for broad age bands (30–69 years and 70–100 years).

We explored whether the risk of death involving COVID-19 in disabled people changed during the pandemic by extending the models to allow for time-dependent coefficients that were free to vary according to wave of the pandemic (wave 1: Jan 24 to Sept 11, 2020; wave 2: Sept 12, 2020, to Feb 28, 2021).

Disability status was missing in 3·2% of Census returns. Missing Census responses were imputed using nearest-neighbour donor imputation, the methodology used by the Office for National Statistics across all 2011 Census variables.[25] GPES data on BMI were converted into a categorical variable and individuals with missing BMI values were placed into an unknown category.

All statistical analyses were conducted using R, version 3.5. Cox proportional hazards models were implemented using the survival package (version 2.41-3).[26]

Role of the funding source

There was no funding source for this study.

	All deaths		Total COVID-19 deaths		Wave 1 COVID-19 deaths*		Wave 2 COVID-19 deaths†	
	Number of deaths	Age-standardised mortality‡ (95% CI)	Number of deaths	Age-standardised mortality‡ (95% CI)	Number of deaths	Age-standardised mortality‡ (95% CI)	Number of deaths	Age-standardised mortality‡ (95% CI)
Men								
Non-disabled	131 056	1413 (1405–1422)	26 459	291 (287–295)	10 294	196 (192–200)	16 165	429 (422–436)
Limited a little	69 570	2451 (2430–2472)	15 703	535 (526–545)	6213	354 (344–364)	9490	800 (782–818)
Limited a lot	61 639	3931 (3897–3965)	14 469	899 (883–915)	5892	614 (597–631)	8577	1322 (1292–1352)
Women								
Non-disabled	107 423	980 (974–986)	17 338	162 (159–164)	6376	102 (100–105)	10 962	248 (243–253)
Limited a little	79 627	1681 (1666–1696)	15 160	318 (312–324)	5771	200 (194–207)	9389	488 (476–500)
Limited a lot	78 063	2973 (2946–2999)	16 084	627 (616–639)	6388	408 (395–420)	9696	947 (925–970)

*Jan 24 to Sept 11, 2020. †Sept 12, 2020, to Feb 28, 2021. ‡Deaths per 100 000 person-years at risk.

Table 1: **Number of deaths and age-standardised all-cause mortality and mortality involving COVID-19, stratified by sex, self-reported disability status, and wave of the pandemic**

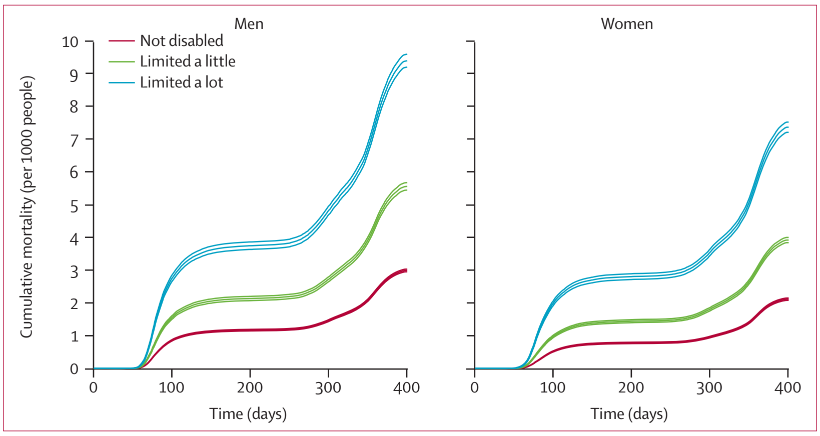

Figure 1: **Age-adjusted cumulative COVID-19 mortality between Jan 24, 2020, and Feb 28, 2021, by disability status and sex**
Upper and lower lines of each colour represent the upper and lower bounds of the bootstrapped 95% CI.

Results

The study included 29 293 845 adults aged 30–100 years (median age 55 years [IQR 43–68]) in England, 13 806 623 (47%) of whom were male and 15 487 222 (53%) of whom were female. 5 050 348 (17%) participants reported being disabled on the 2011 Census: 3 038 772 (10%) reported being limited a little and 2 011 576 (7%) reported being limited a lot (appendix pp 2–13). Mean follow-up time was 397·0 days (SD 30·9).

Compared with non-disabled people, disabled people tended to be older, were more likely to have no qualifications, were more likely to have a pre-existing health condition, and were more likely to have been admitted to hospital in the past 3 years (appendix pp 14–16). Disabled people were also more likely than non-disabled people to live in a care home, single-adult household, social rented accommodation, a household where the household reference person was in a non-managerial occupation, and in the most deprived areas.

527 378 deaths were recorded during follow-up: 238 479 (45%) among non-disabled people, 149 197 (28%) among disabled people who were limited a little, and 139 702 (26%) among disabled people who were limited a lot. 105 213 (20%) deaths involved COVID-19: 43 797 (42%) in non-disabled people, 30 863 (29%) in disabled people who were limited a little, and 30 553 (29%) in disabled people who were limited a lot. 40 934 (39%) of the deaths involving COVID-19 were in wave one (16 670 [41%] in non-disabled people, 11 984 [29%] in disabled people who were limited a little, and 12 280 [30%] in disabled people who were limited a lot), and 64 279 (61%) were in wave two (27 127 [42%] in non-disabled people, 18 879 [29%] in disabled people who were limited a little, and 18 273 [28%] in disabled people who were limited a lot).

The age-standardised all-cause mortality was substantially higher for both groups of disabled people than for non-disabled people (table 1). Age-standardised mortality for death involving COVID-19 was also substantially higher for both groups of disabled people than for non-disabled people, both for the whole follow-up period and in each of the two waves of the COVID-19 pandemic. The relative difference in mortality involving COVID-19 between disabled and non-disabled people was most pronounced in younger age groups and decreased with age (appendix p 17).

Age-adjusted cumulative mortality involving COVID-19 increased more rapidly for disabled people than for non-disabled people at the start of the pandemic and remained consistently higher thereafter (figure 1). At the end of the follow-up period, cumulative mortality involving COVID-19 was 2·99 per 1000 people (95% CI 2·95–3·03) for non-disabled men, 5·55 per 1000 people (5·44–5·67) for disabled men who were limited a little, and 9·39 per 1000 people (9·20–9·59) for disabled men who were limited a lot. Cumulative mortality involving COVID-19 was 2·11 per 1000 people (2·08–2·15) for non-disabled women, 3·92 per 1000 people (3·84–4·00) for disabled women who were limited a little, and 7·36 per 1000 people (7·20–7·52) for disabled women who were limited a lot.

Age-adjusted hazard ratios (HRs) showed that rates of death involving COVID-19 were substantially higher for

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both groups of disabled people than for non-disabled people (HR 3·05 [95% CI 2·98–3·11] for men who were limited a lot, 1·88 [1·84–1·92] for men who were limited a little, 3·48 [3·41–3·56] for women who were limited a lot and 2·03 [1·98–2·08] for women who were limited a little; figure 2). Including residence type in the model partly explained the excess rates of mortality involving COVID-19 for disabled people who were limited a lot, but HRs were largely unchanged for disabled people who were limited a little (figure 2). Additional adjustment for geographical (local authority district and population density), socioeconomic, and demographic factors further reduced HRs for both groups of disabled people. The inclusion of pre-existing health conditions in the model also further reduced excess rates of mortality involving COVID-19. However, across all models, the rate of death involving COVID-19 remained elevated for both groups of disabled people compared with non-disabled people (HR 1·35 [1·32–1·38] for men who were limited a lot; 1·21 [1·18–1·23] for men who were limited a little; 1·55 [1·51–1·59] for women who were limited a lot; and 1·28 [1·25–1·31] for women who were limited a little).

In post-hoc subgroup analyses for broad age bands (30–69 years and 70–100 years; p<0·0001 for effect modification by age group), HRs for both groups of disabled people compared with non-disabled people were higher among people aged 30–69 years than among people aged 70–100 years, after adjusting for age (table 2). HRs were higher for women than men for both disabled groups, and this difference was more pronounced in the younger age group (age-adjusted HR among those aged 30–69 years: 8·47 [95% CI 8·01–8·95] for women who were limited a lot, 5·42 [5·18–5·68] for men who were limited a lot). HRs for people aged 30–69 years were lower in the fully adjusted model than in the age-adjusted model for both men and women in both groups of disabled people, but still showed a higher risk of death involving COVID-19 in all groups of disabled people than in non-disabled people (HR 1·91 [95% CI 1·78–2·04] for women who were limited a lot, 1·74 [1·64–1·84] for men who were limited a lot; appendix p 19).

The increased risk of death involving COVID-19 for disabled people compared with non-disabled people was similar in the first and second waves of the pandemic (figure 3).

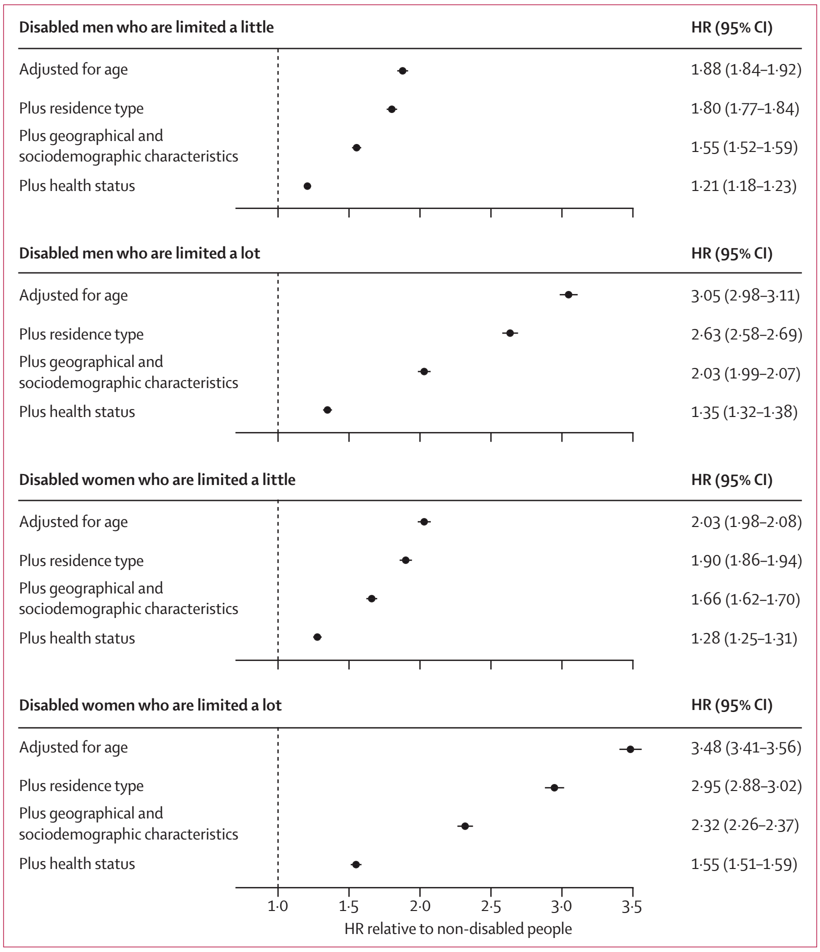

Figure 2: **HRs for death involving COVID-19 for disabled people, relative to non-disabled people, stratified by sex**

Results obtained from Cox proportional hazards regression models adjusted for: (1) age; (2) age plus residence type (private household, care home, or other communal establishment); (3) age and residence type plus geographical (local authority district and population density) and sociodemographic (ethnicity, highest qualification, Index of Multiple Deprivation decile, household characteristics [National Statistics Socio-economic Classification of the household reference person, tenure of the household, household size, family status, household composition, and key worker in household], key worker type, individual and household exposure to disease, and individual and household proximity to others) characteristics; and (4) age, residence type, geography, and sociodemographic characteristics, plus health status (pre-existing health conditions, BMI, and hospital admissions over the previous 3 years). Error bars represent 95% CIs. BMI=body-mass index. HR=hazard ratio.

Discussion

In this large, retrospective cohort study of more than 29 million adults we showed that disabled people were at increased risk of death involving COVID-19 compared with non-disabled people during the first two waves of the COVID-19 pandemic in England. This association was partly explained by residence type, socio-demographics, geography, and pre-existing health conditions, indicating that a combination of these factors contributed to the increased risk. The excess risk of death involving COVID-19 was consistent across both the first and second waves of the pandemic, and was more marked among women than men and among younger people (aged 30–69 years) than older people (aged 70–100 years). Disabled people were also at excess risk for all causes of death during this period; only approximately 21% of deaths among disabled people involved COVID-19 in this study (table 1).

The literature shows an excess risk of COVID-19 mortality associated with learning disabilities. Analyses using the OpenSAFELY platform showed that people with a learning disability were approximately 4–5 times more likely to be admitted to hospital for COVID-19, and 7–8 times more likely to die from causes involving COVID-19 than those without a learning disability.[4] This

	Age-standardised mortality* (95% CI) for death involving COVID-19	Age-adjusted HR (95% CI) for death involving COVID-19
30–69 years old in 2020		
Men		
Non-disabled	58 (57–60)	1 (ref)
Limited a little	160 (151–168)	2·64 (2·50–2·79)
Limited a lot	329 (315–343)	5·42 (5·18–5·68)
Women		
Non-disabled	27 (26–28)	1 (ref)
Limited a little	94 (88–100)	3·35 (3·13–3·58)
Limited a lot	244 (233–256)	8·47 (8·01–8·95)
70–100 years old in 2020		
Men		
Non-disabled	1164 (1147–1182)	1 (ref)
Limited a little	1944 (1911–1977)	1·73 (1·69–1·77)
Limited a lot	3037 (2982–3092)	2·68 (2·62–2·74)
Women		
Non-disabled	667 (655–678)	1 (ref)
Limited a little	1157 (1137–1178)	1·82 (1·78–1·86)
Limited a lot	2064 (2026–2101)	2·98 (2·91–3·05)

HR=hazard ratio. *Deaths per 100 000 person-years at risk.

***Table 2:* Age-standardised mortality and age-adjusted HRs for death involving COVID-19, stratified by age group, sex, and self-reported disability status**

association has also been shown by other studies in the UK[3,6,7] and the USA.[27] Risks are particularly high for people with Down syndrome.[3,4]

By contrast, the literature on the association between disability more broadly, or specific impairment types, and COVID-19 outcomes is extremely sparse. A nationwide cohort study in Korea included 10 237 patients with COVID-19 tracked through health insurance records, of whom 228 died between January and April, 2020.[10] The univariable HR of mortality among people with moderate or severe disability compared with those with no disability was 6·2 (95% CI 4·0–9·7), decreasing to 1·6 (1·0–2·6) after extensive adjustment.[10] Univariable associations also showed an elevated risk for people with mild disability (HR 4·8 [95% CI 3·3–6·8]), which was eliminated after adjustment (1·0 [0·7–1·4]).[10] Moreover, risks of SARS-CoV-2 infection and major adverse clinical outcomes were also higher among disabled people than among non-disabled people.[11] Although this evidence is valuable, the number of events was relatively small, some variables adjusted for are arguably on the causal pathway, and no clear definition of disability was given. We could not identify other relevant studies focused on disability more broadly. The literature is more extensive with respect to specific conditions that are often disabling, including dementia,[27] cerebral palsy,[22] multiple sclerosis,[28] and neurological disorders.[2] Excess mortality among care-home residents is well documented, and is particularly high among people with pre-existing conditions such as dementia.[14]

Evidence is therefore extremely limited on the association between disability and deaths involving COVID-19. Most available data on risk factors for COVID-19 are generated through medical records, often through general practitioner databases.[13] In the UK, learning disability registers linked to general practitioner records were established as part of efforts to reduce health inequalities and poor outcomes experienced by those with learning disabilities.[29] However, disabilities and specific impairment types are often not recorded in medical records. Consequently, although learning disability registers are far from complete, it has been possible to identify people with a learning disability and link them to COVID-19 outcomes,[4] which has not been possible for disability more broadly. Our analyses using disability assessment from the Census data therefore make an important contribution to the literature.

The key strength of our study is that we included more than 29 million adults and had comprehensive linkage to deaths involving COVID-19. Sequential adjustment for a wide range of factors that might confound or mediate the effect of disability was therefore possible. These analyses are consistent with and extend those presented in previous Office for National Statistics reports for deaths involving COVID-19 among disabled people, the most recent of which covered up to November, 2020, and therefore missed most of the second wave of the pandemic.[19,20]

A potential critique of our study is that our measure of disability was self-reported and did not include information from clinical records. This definition relies on an individual's perception and is therefore subjective in terms of the presence and severity of disability. We were also not able to distinguish between risks experienced by disabled people with mental or physical conditions, which remains a key priority. However, the measure we used complies with the definition of disability in the Equality Act 2010 for Great Britain and the Disability Discrimination Act 1995 for Northern Ireland, which provide a legal basis for protection of disabled people against discrimination and unfair treatment in the UK. Hence, we identified disabled people in a similar way to policy makers. It would be useful to undertake analyses focusing on clinically diagnosed impairment, which is more objectively measured and would allow disaggregation of data by impairment type to identify the most at-risk groups.

An important limitation of our study is that the measure of disability was from 2011. Consequently, information bias is highly likely, particularly as many older people will have developed impairment in the past decade and will be recorded incorrectly as not disabled, while others who were disabled in 2011 might not be disabled in 2020 as a result of medical or other interventions. Data were not available on the frequency of disability status change in the follow-up period in this study group. However, the most likely result is an underestimation of the association between disability and mortality, particularly among older people. We have no reason to believe that there was any substantial misdiagnosis of COVID-19 where it was mentioned on death certificates. Our results might also be affected by survivor bias as our study population comprised people who were alive at the start of the pandemic, but 30% of people who were disabled in 2011 had died before 2020. Many of the measures of socioeconomic status and demographics used in our study were from the 2011 Census, which will also not reflect the situation in 2020 accurately. Where possible, this was addressed by using more up-to-date information (eg, care-home residence and geographical variables). Consequently, adjustment in the models might have been incomplete, possibly contributing towards the residual association. Data were also not available on key potential mediators, such as access to, and quality of, health care. This study focused on mortality outcomes only, although other social, physical, and mental health impacts are likely to be greater among disabled people than among non-disabled people.[30] Finally, the size of the dataset precluded multiple imputation methods for missing Census data; instead, single imputation using nearest-neighbour donor input was used, which might have inflated the statistical precision of Census variables.

In this study we have identified a group at high risk of COVID-19 mortality (particularly those with greater levels of limitations, younger people, and women), who could be a specific focus in the public health response, including testing, shielding, protection in care homes,[31] appropriate and accessible health messaging, and provision of accessible vaccination programmes.[18] Some groups of disabled people are often already prioritised for vaccination or shielding, such as older people, and those in residential care or with specific conditions (eg, learning disabilities or cerebral palsy). Consideration should be given to the expansion of prioritisation criteria, notwithstanding the practical difficulties in identification of disabled people from medical or other routine records.

Sequential adjustment suggested that the excess risk of COVID-19 mortality is partly due to disabled people being disproportionately exposed to a range of generally disadvantageous circumstances, as no single factor explained the results. Disabled people were also at higher risk of death from all causes during the study period, only a fraction of which involved COVID-19. These findings imply a need to improve services and access to health care for disabled people, and tackle the drivers of disadvantage and excess mortality, both during and after the pandemic.

Verification of these findings is required, given the limitation of our measure of disability and the need for data disaggregated by disability type, as well as more data on health inequalities faced by disabled people.[32] Administrative data might be the most useful source of information, since existing cohort studies that measure

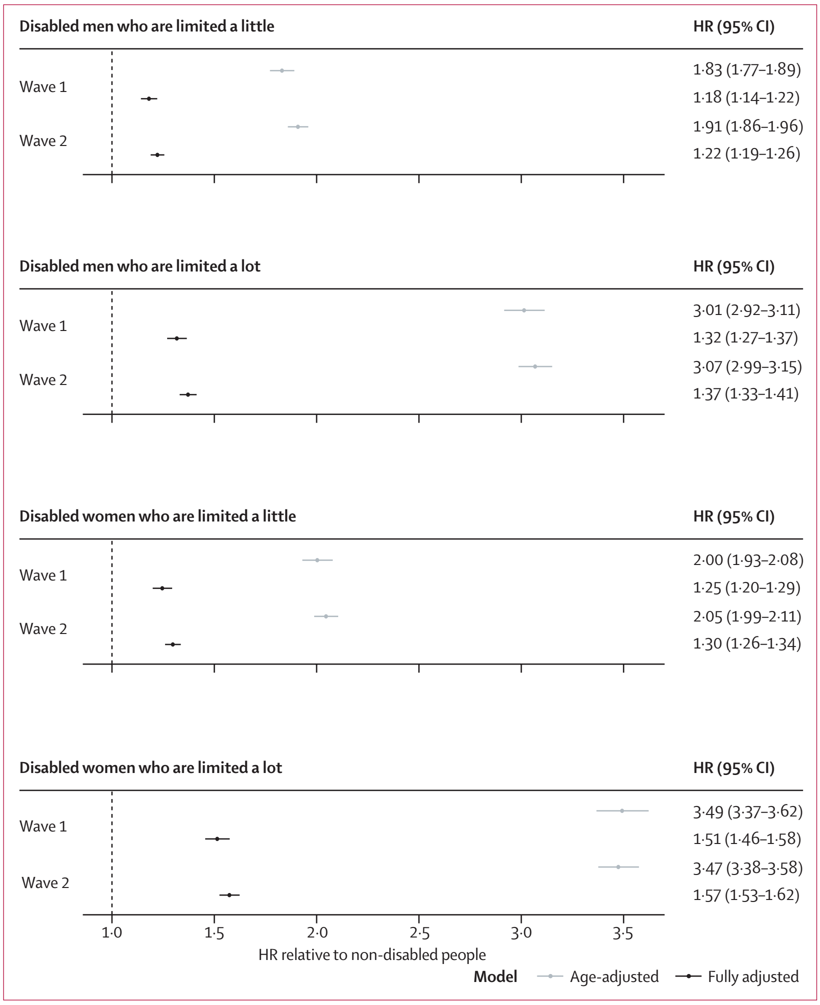

Figure 3: **HRs for death involving COVID-19 for disabled people, relative to non-disabled people, in waves one and two of the pandemic, stratified by sex**

Wave one of the pandemic was defined as Jan 24 to Sept 11, 2020. Wave 2 of the pandemic was defined as Sept 12, 2020, to Feb 28, 2021. Error bars represent 95% CIs. HR=hazard ratio.

disability might be inadequately powered to show associations with COVID-19 deaths. Measures of impairment can be generated within the large and comprehensive UK general practitioner registry and used to estimate the association between different impairments or clinical diagnoses and COVID-19 outcomes. However, doing so is time-consuming, requires multidisciplinary clinical expertise, and would identify people with specific conditions or impairments rather than disability, as per the social model understanding of disability. Another option is to use registry data to explore the association between measures of disability (eg, Swedish disability pension recipients) or impairment types (eg, Finnish Register of Visual Impairment) and COVID-19 and other health outcomes. Health insurance or social security data can also be used to identify people registered with disabilities.[2] Again, these approaches rely on disability or specific impairments being recorded consistently. Consensus is therefore needed on recording of disability in medical and other records.

In conclusion, disability was associated with increased risk of death from causes involving COVID-19, which was largely attributable to a combination of disadvantageous circumstances. Verification of these findings is needed, as well as consideration of how to ensure that the COVID-19 response includes disabled people and responds to their particular needs. Policies can be implemented to tackle mediating factors associated with disability highlighted in this study and ensure inequalities are considered during recovery from the pandemic.[32]

Contributors

All authors conceived the study. MLB, VN, and DA curated the data. MLB did the formal analysis. MLB, DA, VN, and JF did the investigation. MLB, DA, and VN developed the methodology. MLB, DA, VN, JF, and HK were responsible for project administration. MLB, DA, VN, JF, and MG were responsible for resources. MLB, DA, and VN were responsible for software. MLB, DA, VN, and HK supervised the study. MLB, DA, and VN validated the data. MLB was responsible for data visualisation. MLB, JF, and HK wrote the original draft. MLB, DA, VN, JF, MG, CD, and HK reviewed and edited the manuscript. All authors approved the final manuscript. MLB, DA, VN, JF, and MG had access to the underlying data. Due to legal restrictions, CD and HK had access only to the aggregate data. All authors had access to and verified the validity of the aggregate results.

Declaration of interests

We declare no competing interests.

Data sharing

Deidentified participant data and a data dictionary are available via the Secure Research Service for Accredited Researchers. Analytical code is available on request to the corresponding author. As part of the Office for National Statistics wider research strategy, we are working towards making analytical code openly available.

For **information on the Secure Research Service for Accredited Researchers** see https://www.ons.gov.uk/aboutus/whatwedo/statistics/requestingstatistics/approvedresearcherscheme

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