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1	The widening of inequalities in COVID-19 years of life lost							
2	from 2020 to 2021: a Scottish Burden of Disease study							
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25 Abstract

26

27 Background

Previous studies have highlighted the large extent of inequality in adverse COVID-19 health
outcomes. Our aim was to monitor changes in overall, and inequalities in, COVID-19 years
of life lost to premature mortality (YLL) in Scotland from 2020 and 2021.

31

32 Methods

Cause-specific COVID-19 mortality counts were derived at age-group and area-deprivation
 level using Scottish death registrations for 2020 and 2021. YLL was estimated by multiplying
 mortality counts by age-conditional life expectancy from the Global Burden of Disease 2019
 reference life table. Various measures of absolute and relative inequality were estimated for
 triangulation purposes.

38

39 Results

40 There were marked inequalities in COVID-19 YLL by area deprivation in 2020, which were

41 further exacerbated in 2021; confirmed across all measures of absolute and relative

42 inequality. Half (51%) of COVID-19 YLL was attributable to inequalities in area deprivation in

43 2021, an increase from 41% in 2020.

44

45 Conclusion

46 Despite a highly impactful vaccination programme in preventing mortality, COVID-19

47 continues to represent a substantial area of fatal population health loss for which inequalities

- 48 have widened. Tackling systemic inequalities with effective interventions are required to
- 49 mitigate further unjust health loss in the Scottish population from COVID-19 and other

50 causes of ill-health and mortality.

What is already known on this topic?

- Previous studies have highlighted that COVID-19 has a disproportionate impact on health outcomes, with those living in deprived areas suffering the worst outcomes.
- A UK-wide vaccination campaign has successful averted many deaths from COVID-19, however inequalities in vaccination uptake persist through the first, second, and subsequent doses.

What this study adds

- This study has highlighted that the high level of inequality in COVID-19 mortality was further exacerbated in 2021, with half of fatal years of life lost to COVID-19 being inequality-attributable.
- The widening of estimates of inequality was driven by two factors: unequal improvements in COVID-19 mortality; and a disproportionately higher number of deaths from younger ages in deprived areas.
- Despite the success in averting COVID-19 mortality from vaccination, the impact of COVID-19 mortality in 2021 was substantial and comparable to pre-pandemic population health losses from lung cancer or drug use disorders.

How this study might affect research, practice or policy

 This study underscores the importance of tackling systemic inequalities with effective interventions to mitigate further unjust health loss in the Scottish population from not only COVID-19, but from other causes of health loss.

53 Introduction

Regular reporting of cases and deaths from COVID-19 has continued into 2022 as the 54 55 pandemic recently reached a two-year duration. These data have been required to develop 56 the necessary intelligence to inform policy decisions on issues such as: general physical distancing measures; severity of any requirement for localised restrictions; and, prioritising 57 and targeting of vaccination efforts.¹ Previous evidence has highlighted the substantial 58 overall impact of COVID-19 on the population health of Scotland, by illustrating that it was a 59 leading cause of disease burden in 2020, second only to heart disease.² Furthermore, the 60 disease burden was not shared equally amongst areas experiencing different levels of 61 deprivation, with high levels of absolute and relative inequality prevailing.³ 62

63

The United Kingdom embarked on a mass vaccination programme in December 2020. Since 64 then, research studies have evidenced the positive impact of vaccination in mitigating severe 65 outcomes from COVID-19 infection in Scotland through reducing the severity of cases, and 66 the number of deaths.^{4,5} The vaccination programme has been successful in achieving high 67 68 population-level uptake in all constituent nations of the United Kingdom.⁶ As at the end of 2021, 91% of the 18+ years Scottish population had received the first dose, 88% the second 69 dose, and 67% the third dose.⁷ COVID-19 deaths have been lower in 2021 compared to 70 2020, although during winter in early 2021 – when the vaccination programme was in its 71 infancy - there was a profound number of COVID-19 deaths during a biphasic second 72 wave.8 73

74

Modelling studies have illustrated the huge success in averting deaths from COVID-19.⁹
However, in the context of relaxation of protection measures comes increases in the number
of cases. Understanding the combined impact of these factors using summary measures of
population health is useful, to understand how they are driving changes in population health
needs.

80

81 Our aim was to monitor changes in overall, and inequalities in, COVID-19 years of life lost to 82 premature mortality (YLL) in Scotland from 2020 and 2021.

83

84 Methods

Death registrations were sourced from National Records of Scotland (NRS) for 2020 and 85 2021, including the age, sex and postcode of residence of the individual that died.¹⁰ Deaths 86 87 in 2020 were from the final register of deaths, whereas deaths in 2021 are treated as provisional. COVID-19 deaths were defined using ICD-10 codes U07.1 or U07.2 as the 88 89 underlying cause of death. Our dataset was generated on 08 March 2022, to allow additional 90 time to capture the later registrations of deaths occurring towards the end of 2021. Each death record was matched to a Scottish Index of Multiple Deprivation (SIMD) 2020 91 deprivation fifth, based on their postcode of residence.¹¹ SIMD uses seven domains to 92 93 examine the extent of area deprivation: income; employment; education; health; access to 94 services; crime; and, housing.

95

Mortality counts were aggregated by five-year age-group. The under-5 years age-group was split into under 1 year and 1 to 4 years, and the upper open-ended age-group was set at 95 years and above, to align with the Global Burden of Disease (GBD) 2019 reference life table.¹² YLL estimates were derived by multiplying age-group based mortality counts by the age-conditional remaining life expectancy from the GBD 2019 reference life table.

101

All analysis was carried out at the level of age-group and SIMD quintile to facilitate the
 calculation of age-standardised rates (ASR). All ASR findings are presented per 100,000
 population. ASR using mid-year population estimates were calculated directly to the 2013
 European Standard Population to facilitate comparisons.^{13,14} ASR removes the contribution
 of differences in underlying population structure between SIMD quintiles. ASR were used to

measure inequality using several metrics. The absolute and relative range differences in
ASR were estimated between the most and least deprived fifths. The Relative Index of
Inequality (RII) and Slope Index of Inequality (SII) were also measured, which involved fitting
a linear regression to the ranked SIMD quintiles and YLL ASR. To estimate the RII, the SII
rate was divided by the total ASR YLL rate. YLL attributable to inequalities in area
deprivation were estimated using the least deprived quintile as a reference group.

114 Sensitivity analysis on the indicators of relative inequality was carried out using the last six-115 month period of 2021. This was to detect whether the 2021 estimate was strongly influenced 116 by lower periods of vaccination uptake.

117

118 **Results**

119 There were 6,163 COVID-19 deaths in 2020, which decreased to 4,670 in 2021 (Table 1).

120 YLL decreased from 94,871 in 2020 to 84,954 in 2021. In 2020, COVID-19 impacted

121 population health for a 10-month period, whereas it impacted for the full 12-month calendar

122 year 2021, which may underplay the extent of progress in 2021. Therefore, the reduction in

the monthly average rate between 2020 and 2021 was larger than the changes in the annual

rate for deaths and YLL. Average monthly deaths and YLL in 2021 were 37% and 25%

lower, respectively, when compared with 2020. The YLL per death increased to 18.2 in 2021

126 from 15.4 in 2020. Increases in YLL per death were highest in the most, compared to least,

deprived areas indicating that the extent of this increase was disproportionate.

128

129

Table 1. Summary of measures of COVID-19 mortality in Scotland, 2020 and 2021
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There were marked inequalities in COVID-19 YLL by area deprivation in 2020, which were
further exacerbated in 2021, a result confirmed across all measures of absolute and relative
inequality (Table 2).

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Table 2. Inequalities in the age-standardised COVID-19 YLL rate in Scotland, 2020 and
 2021

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140

141 There was an 11% reduction in the Scottish national YLL ASR between calendar years. ASR were lower in 2021 for all deprivation quintiles. However, ASR in the most deprived areas 142 were only 3% lower, compared to 26% lower in the least deprived areas. The absolute 143 difference between the ASR in most and least deprived areas increased from 2,024 to 2,217. 144 145 In 2021 the relative difference in ASR indicated that COVID-19 YLL was 3.8 times higher in the most, compared to least, deprived areas, an increase from 2.9 in 2020. The RII also 146 increased from 1.37 in 2020, to 1.70 in 2021, which means that the ASR in the most 147 deprived areas in 2021 was 85% higher than the Scottish national ASR. The absolute 148 149 difference between the most and least deprived areas, measured by SII, also increased from 2,414 in 2020 to 2,652 in 2021. The ASR attributable to differences in area deprivation was 150 41.0% in 2020. This increased to 51.1% in 2021, indicating that over half of the COVID-19 151 YLL ASR was attributable to inequalities in area deprivation. Sensitivity analysis on the 152 153 indicators of relative inequality illustrated slightly higher levels of relative inequality in the last 154 six months of 2021, compared to the entire 2021 calendar year period (Supplementary Table 155 1).

156

157 **Discussion**

The marked inequalities in COVID-19 YLL in 2020 were further exacerbated in 2021, to the extent that approximately half of COVID-19 YLL was attributable to inequalities in area

160 deprivation. The widening of inequalities in 2021 was confirmed across all measures of 161 absolute and relative inequality. The combination of two factors drive the widening of 162 estimates of inequalities in COVID-19: disproportionate improvements in COVID-19 163 mortality; and unequal changes in the age of death. Despite reductions in COVID-19 164 mortality, reductions were the smallest in the most deprived areas. This was augmented by 165 increases in YLL per death, where the largest increases were in the most deprived areas. 166 Our sensitivity analysis suggested that relative inequalities in the last six months of 2021 167 were slightly higher, which reflect periods of high vaccination uptake.

168

In October 2020, the Scottish Government implemented tiered local protection levels. All
mainland local authorities imposed the highest level of protections during the first five
months of 2021, and all areas moved to the lowest levels from mid-July 2021.¹⁵ As these
restrictions were driven by specific indicators, local differences emerged at different times.
Although areas with the highest levels of deprivation often had the highest protections
imposed, such as Glasgow City, similar levels were also imposed in areas with lower levels
of deprivation, such as East Renfrewshire.

176

Published estimates in early February 2022 highlighted that although overall vaccination 177 rates were high, rates varied with level of deprivation.¹⁶ In all persons eligible for vaccination, 178 there was an 8-percentage point (pp) difference in uptake between the most compared to 179 least deprived areas for the first dose. Inequalities in uptake further increased for the second 180 181 dose (11-pp) and the third or booster dose (20-pp). Inequalities in vaccination uptake is a likely key contributor to our findings. Factors such as job type and the ability to work from 182 home, could also influence the direct risk of infection. Structural inequalities, such as the 183 184 unequal distribution of income, wealth, and power drive inequality in underlying general health. This in-turn leads to higher levels of vulnerability, disproportionately should ered by 185 members of Scotland's most deprived communities. 186

A limitation of this study is that it does not capture the Years Lived with Disability (YLD) 187 through living with ill-health due to COVID-19, to estimate disability-adjusted life years 188 (DALYs).¹⁷ Previous studies have indicated that contribution of YLD to DALYs is likely to be 189 low, however with the large increase in case numbers and mortality improvements, the YLD 190 191 contribution in 2021 would be expected to be slightly higher than reported in 2020.¹⁸ The 192 contribution of YLD to DALYs is also likely to be driven by the severity of the dominant variant, which would change over time. However, as uncertainties over the extent of the 193 194 prevalence, duration, and disability from long COVID persist, monitoring the fatal population 195 health impact using YLL yields important insights. The YLL findings alone would be enough to frame the population health loss from COVID-19 mortality as being similar to the pre-196 pandemic population health losses from lung cancer or drug use disorders.¹⁹ A strength of 197 our study lies in the use of high-quality death registration data.²⁰ Furthermore, utilising an 198 199 internationally agreed consensus on the valuation of life lost is a strength, allowing for comparability with other pre-pandemic causes of death, and estimates of COVID-19 YLL 200 from other countries.²¹ 201

202

Despite a highly impactful vaccination programme in preventing mortality, COVID-19
continues to represent a substantial area of fatal population health loss for which inequalities
have widened. As COVID-19 infection has disproportionately impacted the Scottish
population due to systemic inequality, the indirect adverse impacts as a result of protective
measures have the potential to further widen inequalities.²² Tackling systemic inequalities
with effective interventions are required to mitigate further unjust health loss in the Scottish
population.²³

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302		

303 **Declarations**

304

305 **Contributors**

- 306 GW, IG, OH, GM and DS generated the idea for the study. GW, EF and GM developed the
- 307 methodological approach. GW and EF carried out all analyses. GW drafted the original
- 308 manuscript. All other authors provided critical input into the interpretation of the results,
- 309 revisions to the manuscript, and approved the final draft.

310

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- 315 Organization.
- 316

317 Competing interests

318 All other authors declare that they have no competing interests.

319

- 320 **Patient consent for publication**
- 321 Not required.

- 323 Twitter
- 324 Grant MA Wyper (@GMAWyper)

Area deprivation fifth	2020			2021			2020 to 2021 change			
	Deaths	YLL	YLL	Deaths	YLL	YLL	YLL		YLL per death	
			per			per	Ν	%	Ν	%
			death			death				
Scotland	6,163	94,871	15.4	4,670	84,954	18.2	-9,916	-10.5%	+2.8	+18.2%
[1] Most deprived fifth	1,674	28,740	17.2	1,410	28,563	20.3	-176	-0.6%	+3.1	+18.0%
[2]	1,427	22,170	15.5	1,133	20,928	18.5	-1,242	-5.6%	+2.9	+18.9%
[3]	1,156	17,076	14.8	832	14,297	17.2	-2,779	-16.3%	+2.4	+16.3%
[4]	1,031	15,030	14.6	732	12,385	16.9	-2,645	-17.6%	+2.3	+16.1%
[5] Least deprived fifth	875	11,855	13.5	563	8,781	15.6	-3,074	-25.9%	+2.0	+15.1%

Table 1. Summary of measures of COVID-19 mortality in Scotland, 2020 and 2021

'YLL' denotes years of life lost to premature mortality; 'N' denotes number; '%' denotes percentage; Numbers have been rounded, which could result in small differences in displayed totals and

annual changes as these have been calculated from the source data.

Table 2. Inequalities in the age-standardised COVID-19 YLL rate in Scotland, 2020 and 2021

Metric	2020	2021
YLL rate (ASR per 100,000)		
Scotland	1,761	1,559
[1] Most deprived fifth	3,094	3,005
[2]	2,103	1,952
[3]	1,480	1,232
[4]	1,324	1,082
[5] Least deprived fifth	1,070	788
Measures of inequality		-
Absolute difference between most and		
least deprived fifth (ASR per 100,000		
population)	2,024	2,217
Relative difference between most and		
least deprived fifth	2.89	3.81
RII	1.37	1.70
SII (ASR per 100,000 population)	2,414	2,652
Attributable YLL (%)	41.0%	51.1%

'YLL' denotes years of life lost to premature mortality; 'ASR' denotes age-standardised rate; 'RII' denotes relative index of inequality; 'SII' denotes slope index of inequality; 'attributable YLL' is the

theoretical percentage of the YLL rate that could have been averted if all socioeconomic groups had the same YLL ASR rate as the least deprived group.