Comparative incidence of diabetes following hospital admission for COVID-19 and pneumonia: a cohort study

Short running title: Diabetes following COVID-19 and pneumonia

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People discharged from hospital post COVID-19 had higher incidence of diabetes than general population but no clear evidence of higher incidence compared to those admitted for pneumonia

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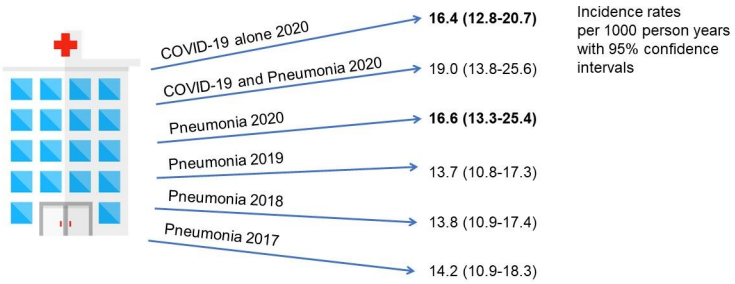
Incident diabetes rates after discharge from hospital



No robust evidence of a COVID-19 impact on incidence of diabetes beyond the effects of an inflammatory insult

Abstract

Objective: The incidence of diabetes may be elevated following COVID-19 but it is unclear whether this is specific to SARS-CoV-2 infection, associated with shared risk factors for severe COVID-19 and diabetes and/or a generic risk following illness.

Research design and methods: People admitted to hospital for COVID-19 and/or pneumonia between 1st April 2020 and 31st August 2020 in England were linked with the National Diabetes Audit to identify incident diabetes post discharge up to 31st March 2021. Comparator cohorts admitted with pneumonia over the same dates in 2017, 2018 and 2019 were followed until 31st March 2018, 31st March 2019 and 31st March 2020 respectively. Poisson regression models were used to calculate adjusted diabetes incidence rates.

Results: Using the cohort of people discharged from hospital following a diagnosis of COVID-19 without pneumonia in 2020 as the standard population (incidence rate 16.4 per 1000 person-years (95% CI 12.8-20.7), adjusting for age, sex, ethnicity and deprivation gave incidence rates of 19.0 (95% CI 13.8-25.6) and 16.6 (95% CI 13.3-20.4) per 1000 person-years for those admitted for COVID-19 with pneumonia and pneumonia without COVID-19 in 2020. These rates are not significantly different from those found after hospital admission for pneumonia in 2019, 2018 and 2017 (13.7 (95% CI 10.8-17.3), (13.8 (95% CI 10.9-17.4), 14.2 (95% CI 10.9-18.3) per 1000 person-years respectively).

Conclusions: Our data do not support a clear impact of COVID-19 on the incidence of diabetes compared to risks in several comparators groups including contemporaneously assessed risks in people hospitalised with pneumonia.

Article Highlights

- A higher incidence of diabetes following acute illness with COVID-19 has been noted but it is unclear whether this finding reflects shared risk factors, the physiological stress of an acute infection or a specific impact of infection with the SARS-CoV-2 virus.
- People admitted to hospital with COVID-19 had higher post-discharge incidence of diabetes than the general population in 2020/21.
- When compared to people who had been admitted to hospital with a different acute infection (pneumonia) both in 2020 and in previous years, no clear evidence of a higher incidence of diabetes in those hospitalised with COVID-19 emerged.

Introduction

Following the spread of COVID-19 throughout the world in early 2020 there has been concern that a period of illness with COVID-19 may induce an increased incidence of new onset diabetes. Previous studies of incidence have generally compared people who have been infected with SARS-CoV-2 or become ill with COVID-19 with contemporaries who did not become infected or severely ill (1). However, there is evidence of higher incidence of diabetes following severe illness and admission to an intensive care unit irrespective of the reason for admission (2). Therefore, comparing the incidence of diabetes in those who have recently experienced an acute infection to those without evidence of infection may not accurately identify specific COVID-19-related risks of incident diabetes.

The aim of this study was to assess the incidence of diabetes following acute illness with COVID-19 compared to people who had experienced a similar infectious illness by linking national administrative records on hospitalisations to the National Diabetes Audit.

Methods

Data sources

Hospital Episode Statistics provide a record of all NHS hospital admissions in England (3). Each episode of care is reported and relevant diagnoses are coded with the International Classification of Diseases version 10. Each individual can be tracked with a unique NHS number which facilitates linkage to the National Diabetes Audit (NDA). The NDA has collated data on people with diagnosed diabetes registered with a primary or specialist healthcare provider in England and Wales

since 2003 (4). Individuals are included in the NDA if they have a valid code for diabetes mellitus (excluding gestational diabetes) in their electronic health record. Demographic and clinical data are extracted from general practice electronic clinical systems using the General Practice Extraction Service (a national centralised data collection service for England) and are supplemented with data submitted by specialist diabetes services. The NDA included data from 98.2%, 97.9%, 99.2% and 99.2% of general practices in England for 1st January 2017 to 31st March 2018, 1st January 2018 to 31st March 2019, 1st January 2019 to 31st March 2020 and 1st January 2020 to 31st March 2021 respectively (5,6). We have recently outlined the legal bases for the data collections and linkages (7).

Cohorts

The aim of this analysis was to assess the incidence of diabetes following acute illness with COVID-19 and comparator groups. The latter comprised people who had been hospitalised for a similar non COVID-10 illness. This allowed the analysis to investigate whether there may be a specific association between COVID-19 and incident diabetes or whether the incidence of diabetes following acute COVID-19 illness rather reflects shared risk factors and/or is linked to the stress of an acute illness. The unique and novel nature of the COVID-19 illness meant that identification of a similar illness was difficult. However, people admitted to hospital with pneumonia was identified as the best available comparator group.

Six cohorts of people were identified. Each cohort included people aged 20 years and older admitted to NHS hospitals in England and discharged alive. The first three cohorts, all discharged between 1st April and 31st August 2020, consisted of: (1)

people with a diagnosis of COVID-19 (ICD-10 codes U07.1, U07.2 and U10) but not pneumonia (ICD-10 codes J12-18) (COVID-19 without PNA 2020); (2) people with a diagnosis of pneumonia without COVID-19 (PNA without COVID-19 2020); people with a diagnosis of COVID-19 and pneumonia (COVID-19 + PNA 2020). People who had a diagnosis of diabetes prior to discharge (n=52,437) or within 14 days of discharge (n=550) were excluded from the analysis.

Three further cohorts of people admitted to hospital for pneumonia with a diagnosis of pneumonia (ICD-10 codes J12-18) and discharged alive were identified: (4) between 1st April 2019 and 31st August 2019 (PNA-2019); (5) between 1st April 2018 and 31st August 2018 (PNA-2018); (6) between 1st April 2017 and 31st August 2017 (PNA-2017). People who had a diagnosis of diabetes prior to discharge (n=27,960 for those admitted in 2019, n=25,700 for those admitted in 2018, n= 22,390 in 2017) or within 14 days of discharge (n=125 for those admitted in 2019, n=125 for those admitted in 2018, n=130 for those admitted in 2017) were excluded from the analysis.

Outcomes

The outcome was diagnosis of diabetes newly recorded in the NDA at least two weeks after hospital discharge and: by 31st March 2021 in those hospitalised in 2020; by 31st March 2020 for those discharged following pneumonia in 2019; by 31st March 2019 for those discharged following pneumonia in 2018; and by 31st March 2018 for those discharged in following pneumonia in 2017. The primary outcome was diagnosis of diabetes of any type but as the physiological pathways for the development of type 1 and type 2 diabetes vary supplementary analyses were conducted for each. The first supplementary analysis presents data for those who

had a diagnosis of type 2 diabetes recorded in the observation period. However, because there may be uncertainty about the type of diabetes at diagnosis a second supplementary outcome was included of diabetes unlikely to be type 1 comprising only individuals who did not receive a prescription for insulin in the 26 weeks following diagnosis. A sensitivity analysis including all diagnoses recorded after the date of discharge from hospital was undertaken.

Statistical analysis

Incidence rates per 1000 person-years were calculated for all people, by sex, by ethnicity and by quintiles of deprivation. Confidence intervals were calculated using Bryar's method. Incidence rates, standardised to the age profile of the 59,605 people discharged alive following hospitalisation for COVID-19 without pneumonia, were calculated. To simultaneously adjust for the influences of age, sex, deprivation and ethnicity on the incidence of diabetes, Poisson regression models were created. Resulting rate ratios and the age, sex, deprivation and ethnicity adjusted incidence of diabetes per 1000 person-years for a cohort matching the characteristics of people discharged alive following a hospital admission for COVID-19 without a concurrent diagnosis of pneumonia between 1st April and 31st August 2020 are reported.

Results

The analysis followed 58,091 people discharged alive in 2020 following hospitalisation with COVID-19 but without pneumonia, 99,951 people discharged following hospitalisation with pneumonia and without COVID-19 and 29,006 discharged following hospitalisation with both COVID-19 and pneumonia. The comparator cohorts were people discharged alive following hospitalisation with

pneumonia comprising 117,148 people in 2019, 110,489 people in 2018 and 102,723 people in 2017.

People 2020 cohorts were younger than those discharged following an admission for pneumonia in previous years. They were also more likely to be of Asian or Black ethnicity but the distribution by socio-economic deprivation was similar across all five groups (see Table 1).

The unadjusted incidence of diabetes following discharge from hospital was 16.7 (95% CI 15.5-17.8) per 1000 person-years in the COVID-19 without PNA 2020 cohort and 20.6 (95% CI 18.8-22.4) per 1000 person-years in the COVID-19+PNA 2020 cohort for the period ending on 31st March 2020 (Supplementary Table 1). The unadjusted incidence of diabetes in the PNA without COVID-19 2020 cohort was similar to that of those discharged following COVID-19 without pneumonia (15.3 (95% CI 14.4-16.2) per 1000 person-years)). These incidence rates were higher than in those found in the PNA 2019 (12.6 95% CI 11.8 -13.3), PNA-2018 (12.3 95% CI 11.6-13.1) and PNA-2017 (12.9 95% CI 12.1-13.8) cohorts.

Across all six cohorts (COVID-19 without PNA 2020, COVID-19 + PNA 2020, PNA without COVID-19 2020, PNA-2019, PNA-2018 and PNS-2017) considered in this analysis, incidence of diabetes following hospitalisation was statistically significantly higher in those living in the more deprived areas and in people from Asian and Black ethnic groups compared to White ethnic groups (see Table 2, Supplementary Table 1). Age standardised incidence rates were similar across each of the six cohorts hospitalised for either COVID-19 and/or pneumonia when stratified by ethnicity and by deprivation (see Table 2). There were, however, no statistically significant

differences by deprivation or ethnicity for any of the six groups in the rate ratios associated with incident diabetes following hospitalisation (Supplementary Table 2).

Using the COVID-19 without PNA 2020 cohort of people as the standard population (incidence rate 16.4 per 1000 person-years,95% CI 12.8-20.7), and adjusting for age, sex, ethnicity and deprivation gave the following incidence rates: 19.0 (95% CI 13.8-25.6) for those in those COVID-19 +PNA 2020 cohort; and 16.6 (95% CI 13.3-20.4) per 1000 person-years for the PNA without COVID-19 2020 cohort. These adjusted incidence rates per 1000 person-years are numerically higher but not significantly different from those found in the PNA-2019 (13.7, 95% CI 10.8-17.3), PNA-2018 (13.8, 95% CI 10.9-17.4) and PNA-17 (14.2, 95% CI 10.9-18.3) cohorts (Figure 1).

Limiting the outcome to diabetes that was recorded as type 2 diabetes in the period following diagnosis gave an age, sex, social deprivation and ethnicity adjusted incidence of 11.6 (95% CI 8.9-14.9) per 1000 person-years for those in the COVID-19 without pneumonia 2020 cohort. After standardising to the COVID-19 without PNA 2020 cohort the incidence of diabetes recorded as type 2 diabetes was 13.8 (9.8-19.0) per 1000 person-years for those in the COVID-19 + PNA 2020 and 11.2 (95% CI 8.9-14.1) per 1000 person-years for the PNA without COVID-19 2020 cohort. These rates are not statistically different from those see in the PNA-2017, PNA-2018 and PNA-2019 cohorts. The incidence of diabetes where insulin was not prescribed in the six months following diagnosis was similar with age, sex, social deprivation and ethnicity adjusted incidences of 14.6 (95% CI 11.5-19.2) per 1000 person-years for the COVID-19 without pNA 2020 cohort, 17.8 (95% CI 12.8-24.4)

per 1000 person-years in the COVID-19+PNA 2020 cohort and 15.3 (95% CI 12.2-19.1) per 1000 person-years in the PNA without COVID-19 2020 cohort. The corresponding incidence rates adjusted for age, sex, deprivation and ethnicity for those in the PNA-2019, PNA-2018 and PNA-2017 cohorts were 12.4 (95% CI 9.6-15.9), 12.8 (95% CI 9.9-16.4) and 12.6 (95% CI 9.5-16.7) respectively (Table 3). The sensitivity analysis which included all incident diabetes with a diagnosis date after discharge from hospital resulted in similar results to the primary analysis presented above (data available on request).

The age standardised incidence of diabetes per 1000 person-years in the general population between 1st April 2020 and 31st March 2021 was lower than in previous years: 5.7 (95% CI 5.6-5.7) in 2020-21 compared to 7.5 (95% CI 7.6-7.6) between 1st April 2019 and 31st March 2020 and 7.6 (95% CI 7.6-7.7) between 1st April 2018 and 31st March 2029.

Discussion

Our analysis shows that, the crude and age adjusted incidence of diabetes following hospitalisation with COVID-19 was similar to that found following hospitalisation with pneumonia in 2020. Both the 2020 crude incidence rates were higher than those found after hospitalisation for pneumonia in 2019, 2018 and 2017. However, there were differences between the ethnicity and deprivation characteristics of people admitted to hospital for COVID-19 in 2020 and those admitted for pneumonia in 2020, 2019, 2018 and 2017. When incidence rates were adjusted for ethnicity and social deprivation the differences between the COVID-19 admissions and the pneumonia admissions were no longer statistically significant.

In summary, although the incidence of diabetes following hospitalisation for COVID in the first, 2020, wave in England was higher than found in the general population, it was similar to that following hospitalisation for pneumonia without COVID-19 in April to August 2020 and only modestly higher than the incidence following hospitalisation for pneumonia for the same months in 2019, 2018 and 2017. It is possible that this difference reflects a higher threshold for admission for acute illness in 2020 at a time of intense pressure on health services. This possibility is consistent with the lower total numbers admitted with pneumonia (without COVID-19) in 2020 (see Supplementary Table 2).

In the general population, the incidence of diabetes is higher in people living in more deprived areas and in those of South Asian and Black ethnicity (7), which may partially explain the higher incidence of diabetes following hospitalisation in 2020. Data on body mass index was not available for these cohorts but given the association between overweight and risk of severe COVID-19 it is possible that the distribution of body mass index varied between those hospitalised with COVID-19 and those with pneumonia and contributed to the small differences in incidence of diabetes in 2020 compared to previous years. We excluded diabetes diagnoses recorded during the hospital admission or within two weeks of discharge to minimise the chances of reverse causality. In sensitivity analysis we noted similar results when we examined patients coded for type 2 diabetes alone and for those who were not prescribed insulin in the first six months of diagnosis, accepting that diagnostic coding of diabetes type is often unreliable in the early months following diabetes diagnosis particularly in the context of concomitant illness.

There are several potential reasons for the incidence of diabetes following hospitalisation with COVID-19 and/or pneumonia being higher than in the general population. For example, we know that several risk factors for type 2 diabetes, including hypertension, sedentary lifestyle and sarcopenic obesity, increase the risk of more severe COVID-19 or indeed pneumonia (8). In addition, the loss of muscle mass during acute illness could increase diabetes risks on the background of several risk factors and, in the case of type 2 diabetes, increased surveillance following discharge is relevant.

In establishing the potential role of COVID-19 as a risk factor for diabetes the fact that a period of severe illness, irrespective of the cause, is associated with an elevated incidence of type 2 diabetes (2) needs to be considered. A US study found that people who had tested positive for the SARS-CoV-2 virus between March 2020 and September 2021 had a higher incidence of diabetes (all types) than both a contemporary control cohort who did not test positive for the virus and a historical cohort prior to the pandemic; incidence of diabetes increased in proportion to the severity of COVID-19 illness (9). A German study showed a higher incidence of type 1 but not type 2 diabetes following COVID-19 in adults who had COVID-19 compared to those who were not diagnosed with COVID-19 (10). In contrast to these observations our study investigated specific cohorts of people who had all experienced an infection severe enough to warrant hospitalisation.

One of the strengths of this study is that it uses population wide data on hospital admissions for severe COVID-19 linked to the National Diabetes Audit which collates data from almost al (over 99%) of general practices in England. However, at the time

of analysis it was only possible to identify incident cases of diabetes up to 31st March 2021 and it is possible that this timeframe is not long enough to clearly capture differential risks of developing diabetes following severe illness with COVID-19. Longer term follow-up of this cohort of people would provide further insight. This study follows people who were severely ill with COVID-19 during the first wave in England. Subsequent waves of infections with different variants of the virus and the widespread vaccination programme have altered the severity and profile of COVID-19 illnesses. Assessment of later cohorts of people infected with SARS-CoV-2 viruses would be needed to identify the possible association between illness with COVID-19 and the incidence of diabetes in these circumstances. There is sometimes uncertainty around the type of diabetes at diagnosis and therefore it was not possible accurately distinguish between the incidence of type 1 and type 2 diabetes. However, we used two proxies – those treated with insulin within 26 weeks of diagnosis and those who were initially identified as having type 2 diabetes - to try and distinguish between types of diabetes. We have noted that the overall recorded incidence of diabetes in the general population in 2020/21 was lower than in previous years, probably due to the disruption to healthcare services and avoidance of non-urgent care during the pandemic. We cannot rule out this distorting the findings presented here. However, we included people admitted to hospital in 2020 with pneumonia but without COVID-19 as a comparator group who would be similarly affected by these factors and therefore finding that the incidence of diabetes does not differ significantly supports the main findings of this analysis. There is evidence that COVID-19 illness is associated with hyperglycaemia that persists after the acute stage (11) but may not always reach the diagnostic criteria for diabetes. This analysis has focused on the incidence of diabetes and has not identified

incident cases of non-diabetic hyperglycaemia who have a high risk of developing hyperglycaemia in the diabetic range in the future. This means that it is possible that there are shifts in the glycaemic profile in people who have been acutely unwell with COVID-19 that have not been fully captured by this analysis.

We conclude that whilst the incidence of diabetes in adults following hospitalisation with COVID-19 (with or without pneumonia) is higher than found in the general population, it is not different to rates seen following pneumonia *without* COVID-19 either in 2020 or in preceding years. Accordingly, our data do not support a clear impact of COVID-19 on the incidence of diabetes when carefully compared to risks in several comparators groups including contemporaneously assessed risks in those hospitalised with pneumonia, at least in the short term. Whilst our findings are derived from a large population-based analysis, additional similar studies with adequate power and comparable design in other national groups and longer term follow up of cohorts like ours would be additionally informative.

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Author Contributions

The study was designed by NH, NS and JV. NH undertook the statistical analysis. All authors reviewed the methods, assisted in writing the paper and reviewed the final manuscript. NH is the guarantor and accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Conflicts of interest

NH is funded by Diabetes UK and NHS England and NHS Improvement. KK, BY and JV are members of the NDA Research Advisory Group. KK has acted as a consultant, speaker, or received grants for investigator-initiated studies for Astra Zeneca, Novartis, Novo Nordisk, Sanofi-Aventis, Lilly, and Merck Sharp & Dohme, Boehringer Ingelheim, Bayer, Berlin-Chemie AG / Menarini Group, Janssen, and Napp. JV is National Clinical Director for Diabetes and Obesity at NHS England & NHS Improvement. NS has received grant from AstraZeneca, Boehringer Ingelheim, Novartis, and Roche Diagnostics, and personal fees from Abbott Laboratories, Afimmune, Amgen, AstraZeneca, Boehringer Ingelheim, Eli Lilly, Hanmi Pharmaceuticals, Janssen, Merck Sharp & Dohme, Novartis, Novo Nordisk, Pfizer, Roche Diagnostics, and Sanofi outside the submitted work. All other authors declare no relationships or activities that could appear to have influenced the submitted work.

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Tables and Figures

Table 1: Characteristics of cohort discharged alive following hospitalisation for COVID-19 and pneumonia

	2020						2019		2018		2017	
	Covid-19 without pneumonia		Pneumonia without COVID-19		Covid-19 and pneumonia		Pneumonia		Pneumonia		Pneumonia	
	n	%	n	%	n	%	n	%	n	%	n	%
Persons	58,091		99,951		29,006		117,148		110,489		102,733	
Males	29,687	51.1%	52,921	52.9%	16,251	56.0%	57,826	49.4%	55,098	49.9%	51,227	49.9%
Women	28,404	48.9%	47,030	47.1%	12,755	44.0%	59,322	50.6%	55,391	50.1%	51,506	50.1%
Age (years)												
20-29	2,559	4.4%	1,999	2.0%	648	2.2%	2,938	2.5%	2,625	2.4%	2,651	2.6%
30-39	4,346	7.5%	4,184	4.2%	1,692	5.8%	4,747	4.1%	4,197	3.8%	4,043	3.9%
40-49	6,042	10.4%	7,319	7.3%	3,218	11.1%	6,531	5.6%	6,290	5.7%	5,689	5.5%
50-59	8,850	15.2%	12,490	12.5%	5,015	17.3%	11,258	9.6%	10,561	9.6%	9,556	9.3%
60-69	8,515	14.7%	15,040	15.0%	4,767	16.4%	17,020	14.5%	16,551	15.0%	15,291	14.9%
70-79	10,611	18.3%	22,214	22.2%	5,439	18.8%	27,883	23.8%	26,412	23.9%	24,149	23.5%
≥80	17,168	29.6%	36,705	36.7%	8,227	28.4%	46,771	39.9%	43,853	39.7%	41,354	40.3%
Median (IQR)	68 (51-82)		74 (59-84)		68 (53-81)		75 (62-85)		75 (63-85)		76 (63-85)	
Ethnicity												
White	42,573	73.3%	80,844	80.9%	20,496	70.7%	99,998	85.4%	95,534	86.5%	89,190	86.8%
Mixed	475	0.8%	504	0.5%	215	0.7%	464	0.4%	349	0.3%	385	0.4%
Asian	2,679	4.6%	2,383	2.4%	1,428	4.9%	2,342	2.0%	2,169	2.0%	1,989	1.9%
Black	2,255	3.9%	2,382	2.4%	1,333	4.6%	1,700	1.5%	1,563	1.4%	1,464	1.4%
Other	3,292	5.7%	3,384	3.4%	1,993	6.9%	2,481	2.1%	2,149	1.9%	1,953	1.9%
Missing	6,817	11.7%	10,454	10.5%	3,541	12.2%	10,163	8.7%	8,725	7.9%	7,752	7.5%
Deprivation												
Most deprived	13,738	23.6%	23,014	23.0%	6,838	23.6%	26,115	22.3%	25,290	22.9%	23,547	22.9%
2nd most deprived	12,886	22.2%	21,308	21.3%	6,615	22.8%	24,480	20.9%	23,076	20.9%	21,561	21.0%
3rd most deprived	11,388	19.6%	19,916	19.9%	5,675	19.6%	23,236	19.8%	22,123	20.0%	20,468	19.9%
2nd least deprived	10,264	17.7%	18,653	18.7%	5,041	17.4%	22,369	19.1%	20,599	18.6%	19,287	18.8%
Least deprived	9,391	16.2%	16,481	16.5%	4,637	16.0%	19,696	16.8%	18,326	16.6%	16,918	16.5%
Missing	424	0.7%	579	0.6%	200	0.7%	1,252	1.1%	1,075	1.0%	952	0.9%

Incident diagnoses	815	1150	510	1105	1025	890

Table 2: Age standardised incidence of diabetes following hospitalisation for COVID-19 and/or pneumonia per 1000 person-years (95% CI)

	2020			2019	2018	2017
	Covid-19 without pneumonia	Pneumonia without COVID-19	COVID-19 and pneumonia	Pneumonia	Pneumonia	Pneumonia
People	16.3 (15.2-17.5)	16.1 (15.2-17.1)	19.4 (17.8-21.2)	13.1 (12.3-14)	12.8 (11.9-13.6)	13 (12.1-14)
Males	16.5 (15-18.1)	16 (14.8-17.3)	17.8 (15.8-20.1)	13.6 (12.5-14.8)	14 (12.8-15.2)	13.8 (12.6-15.2)
Females	16.2 (14.6-18)	16.2 (14.8-17.8)	21.1 (18.4-24)	12.7 (11.5-13.9)	11.6 (10.5-12.8)	12.2 (11-13.5)
Deprivation						
Most deprived	20.1 (17.6-22.7)	20.7 (18.6-23)	24.5 (20.9-28.7)	16 (14.2-17.9)	12.8 (11.2-14.5)	14.3 (12.5-16.4)
2nd most deprived	17.2 (14.9-19.8)	16.3 (14.3-18.4)	20.5 (17.1-24.3)	12.2 (10.6-14)	13.2 (11.4-15.2)	13.4 (11.6-15.5)
3rd most deprived	15 (12.7-17.6)	13.2 (11.3-15.2)	15.9 (12.7-19.8)	12.9 (11.1-14.9)	12.6 (10.7-14.7)	16.6 (14.3-19.1)
2nd least deprived	13.4 (11.1-16.2)	14.5 (12.3-17)	16.4 (12.7-20.8)	12.8 (10.9-15)	14.4 (12.3-16.7)	9.2 (7.6-11.1)
Least deprived	14.7 (12.1-17.7)	13.7 (11.4-16.3)	18.1 (14.1-22.9)	10.3 (8.6-12.3)	10.9 (9-13.2)	10.9 (8.8-13.2)
Ethnicity						
White	13.7 (12.5-15)	14.1 (13.1-15.2)	16.5 (14.6-18.7)	12.5 (11.6-13.4)	12.1 (11.2-13.1)	11.9 (11-12.9)
Mixed	8.2 (3.1-17.8)	12.7 (5.6-25.3)	8.5 (0.6-27.7)	12.1 (1.4-35)	31.6 (10.8-67.2)	41.9 (10.8-78.6)
South Asian	32.1 (23.4-42.3)	39.3 (29.8-50.6)	40.5 (26.9-57.3)	25.1 (18.1-33.8)	25 (17.9-34)	38.1 (28.2-50.3)
Black	24.3 (17.4-32.6)	20.5 (14.8-27.6)	22.3 (14.3-32.6)	14.5 (8.1-23.3)	19.5 (11.4-30.7)	30.7 (19.6-45.1)
Other	26.8 (20-34.8)	26 (20.1-33.1)	29.5 (21.4-39.3)	19.2 (13.5-26.5)	18.7 (12.5-13.6)	15.1 (9.1-14)
Missing	19.7 (16.4-23.4)	18.2 (15.4-21.4)	23.5 (18.8-28.9)	14.3 (11.6-17.4)	12.3 (9.6-15.4)	11.6 (8.8-15)

Table 3: Incidence per 1000 person-years (95% CI) of diabetes where the initial diagnosis code was type 2 diabetes and where insulin was not prescribed in the first six months of diagnosis, adjusted for age, sex, social deprivation and ethnicity

	Year	Incidence of diabetes where type 2 diabetes is recorded	Incidence of diabetes where insulin is not prescribed in the six months following diagnosis
COVID-19 without pneumonia	2020	11.6 (8.9-14.9)	14.6 (11.5-19.2)
Pneumonia without COVID-19	2020	11.2 (8.9-14.1)	15.3 (12.2-19.1)
COVID-19 and pneumonia	2020	13.8 (9.8-19.0)	17.8 (12.8-24.4)
Pneumonia	2019	9.5 (7.4-12.2)	12.4 (9.6-15.9)
Pneumonia	2018	9.6 (7.4-12.4)	12.8 (9.9-16.4)
Pneumonia	2017	9.7 (7.3-12.8)	12.6 (9.5-16.7)

Figure Legend

Figure 1: Crude and adjusted incidence of diabetes per 1000 person-years following hospital admission for COVID-19 and pneumonia