Impact of COVID-19 on the diagnoses, HbA1c monitoring and mortality in people with type 2 diabetes: a UK-wide cohort study involving 13 million people in primary care

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SUMMARY

Background The COVID-19 pandemic has already disproportionately impacted people with diabetes. Timely diagnosis and appropriate monitoring in people with type 2 diabetes (T2D) are necessary to reduce the risk of long-term complications.

Methods We constructed a cohort of 23M patients using electronic health records from 1709 UK general practices registered with the Clinical Practice Research Datalink (CPRD), including 13M patients followed between March and July 2020. We compared trends in diagnoses, monitoring and mortality in T2D, before
and after the first COVID-19 peak, using regression models and 10-year historical data. We extrapolated the number of missed or delayed diagnoses using UK Office for National Statistics data.

**Findings** In England, rates of new T2D diagnoses were reduced by 70% (95% CI 68%-71%) in April 2020, with similar reductions in Northern Ireland, Scotland and Wales. Between March and July, we estimated that there were more than 45,000 missed or delayed T2D diagnoses across the UK. In April, rates of HbA1c testing in T2D were greatly reduced in England (reduction: 77% (95% CI 76%-78%)) with more marked reductions in Northern Ireland, Scotland and Wales (reduction: 84% (83-84%)). Reduced rates of diagnosing and HbA1c monitoring were particularly evident in older people, in males, and in those from deprived areas. Mortality rates in T2D in England were more than 2-fold higher (110%) in April compared to prior trends, but were only 66% higher in Northern Ireland, Scotland and Wales.

**Interpretation** As engagement with the NHS increases, healthcare services will need to manage the backlog and the expected increase in T2D severity due to delayed diagnoses and reduced monitoring. Older people, men, and those from deprived backgrounds with T2D may be groups to target for early intervention.

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INTRODUCTION

The first wave of the COVID-19 pandemic has had major health and economic effects across the world. So far in the UK, there have been more than 50K COVID-related deaths\(^1\) with disproportionate impacts in people with diabetes;\(^2\) nearly a third of all COVID-related deaths having occurred in people with diabetes.\(^3\)

The impact on the NHS, and in particular on diabetes services, has been enormous, with the suspension of much routine care. As we enter the second wave in the UK, there is an urgent need to minimise the harm done through suspension of routine services and to prioritise care and resources to areas of greatest need. The diagnosis of type 2 diabetes occurs almost exclusively in primary care.\(^4\) Timely diagnosis is critically important as delays will increase the risk of long-term complications.

There is limited data on the indirect consequences of the COVID-19 pandemic on the incidence and monitoring of diabetes in primary care. Likewise, there is limited information on COVID-19 impacts on mortality rates in people with diabetes during and after the first wave of COVID-19.

Therefore we used a large primary care longitudinal dataset, broadly representative of the UK population, aiming to compare: i) the UK-wide incidence of type 2 diabetes; ii) the frequency of HbA1c testing; and iii) mortality rates in people with type 2 diabetes, before and after the nationwide COVID-19 lockdown in March 2020. We compared observed and predicted rates using data covering ten years prior to the pandemic.

Since older people and more socially disadvantaged groups have been disproportionally affected by COVID-19 infections, and since the same groups may be more adversely impacted by the unintended consequences of government interventions, we aimed to study variation in outcomes by gender, age group, deprivation level and region.

METHODS

Data sources

We examined primary care electronic health records using the Clinical Practice Research Datalink (CPRD) Aurum and GOLD databases.\(^5,6\) The study population consisted of 19,763,481 patients from 1,368 general practices in England, with a further 36 practices in Northern Ireland (339,153 patients), 195 practices in Scotland (1,804,938 patients), and 110 in Wales (1,277,009 patients).

A total of 22,717,623 patients were included for estimating the expected rates in the pre-COVID-19 period (January 2010-February 2020). In line with guidance from the CPRD’s central administration, Aurum and GOLD databases were analysed separately. The CPRD contains anonymised consultation records and includes patient demographic information, symptoms, diagnoses, medication prescriptions, and date of death. We also examined practice-level Index of Multiple Deprivation (IMD) quintiles,\(^7\) a measure representing an area’s relative level of deprivation, ranked within each UK nation.

Definitions, measurements and clinical coding
To enable comparisons of rates before the COVID-19 outbreak, during its peak and after the peak, we included patient records from January 2010 that established long-term trends and patterns of seasonality. We focussed primarily on reporting observed versus expected rates from 1/3/20 to 10/7/2020. First, we estimated incidence rates of type 2 diabetes diagnoses, new prescriptions for metformin (the most commonly prescribed medication in new-onset type 2 diabetes) and insulin, and rates of HbA1c testing and mortality in people with type 2 diabetes.

Incident type 2 diabetes was identified from Read/SNOMED/EMIS codes used in CPRD GOLD and Aurum (see https://clinicalcodes.rss.mhs.man.ac.uk). The CPRD Aurum and GOLD databases were analysed separately, with data from Aurum restricted to English practices and GOLD providing information on practices in Northern Ireland, Scotland and Wales. The use of two discrete data sources also enabled independent replication of our findings. All code lists and medication lists were verified by two senior clinical academics (a diabetologist: MKR, and a senior academic pharmacist: DMA).

**Study design**

For each patient, we defined a ‘period of eligibility’ for study inclusion which commenced on the latest of: the study start date (1st January 2010); the patient’s most recent registration with their practice; the date on which data from the practice was deemed ‘up-to-standard’ by the CPRD. A patient’s period of eligibility ended on the earliest of: registration termination; the end of data collection from their practice; death. For incident diagnoses and prescriptions, we also applied a ‘look-back’ period during which a patient was required to have been registered for at least a year prior to the event. Flow diagrams illustrating the delineation of the study cohorts using CPRD Aurum and GOLD are presented in supplementary figures 7 and 8 respectively. The denominator for the incidence rates was the aggregate person-months at risk for the whole eligible study population. Mortality and testing rates in people with type 2 diabetes were calculated using the person-months at risk from all those with type 2 diabetes as the denominator. Incidence, mortality and testing rates were stratified by gender, age group (<18, 18-29, 30-44, 45-64, 65-79 and ≥80 years), practice-level deprivation (IMD quintiles) and region (in England) or nation (in the rest of the UK).

**Statistical Analysis**

The data were structured in a time-series format with event counts and ‘person-months at risk’ aggregated (by year and month) with stratification by gender, age group, deprivation quintile and region (or nation in GOLD). Mean-dispersion negative binomial regression models were used to estimate expected monthly event counts from March 2020 onward based on antecedent trends since 2010. The natural logarithm of the denominator (person-months at risk) was used as an offset in each regression model. To account for possible seasonality and long-term linear trends, calendar month was fitted as a categorical variable and time as a continuous variable with the number of months since the start of the study serving as the unit of measurement. For each month studied, observed and expected event counts were converted to rates using the observed person-month denominator. The monthly expected rates, and their 95% confidence intervals,
were plotted against the observed rates. As they share a common denominator, differences between expected and observed monthly rates are expressed as a percentage ‘rate reduction (or increase)’. Extrapolated estimates of the number of missed (or delayed) diagnoses of type 2 diabetes were derived using the discrepancy between observed and expected frequencies from March 2020 onward, and approximations of the proportional representation of the populations of England and the rest of the UK (in CPRD Aurum and GOLD respectively) using data from the Office for National Statistics. Extrapolated estimates of the number of missed (or delayed) diagnoses of type 2 diabetes were derived using the discrepancy between observed and expected frequencies from March 2020 onward, and approximations of the proportional representation of the populations of England and the rest of the UK (in CPRD Aurum and GOLD respectively) using data from the Office for National Statistics. All data processing and statistical analyses were conducted in Stata version 16 (StataCorp LP, College Station, TX). We followed RECORD (REporting of studies Conducted using Observational Routinely-collected health Data) guidance (see online supplement).  

Role of the funding source  
The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

RESULTS

Study cohort  
Our focus was on the impact of the COVID-19 pandemic between March and July 2020. Using the inclusion criteria described in the Study Design, a mixed cohort was utilised consisting of patients whose period of eligibility began before 1st March 2020 and those who became eligible for inclusion between 1st March 2020 and 10th July 2020. The study cohort was comprised of 13,352,550 patients (median (IQR) age: 42 (25, 59) years, 50% female) of whom 707,103 had type 2 diabetes. Of those with type 2 diabetes, the median (IQR) age was 67 (57, 77) years, 44% were female and 25% lived in an area that was in the most deprived quintile compared to the rest of the UK.

Impacts of COVID-19 on diagnosis, prescribing and HbA1c monitoring in England  
In April 2020, the rate of new diagnoses of type 2 diabetes in English primary care was reduced by 70% (95% CI 68% to 71%) compared to the expected rates based on 10-year historical trends (figure 1a; supplementary table 1). Prior to March 2020, rates of type 2 diabetes diagnoses in English practices were higher in older individuals, in men, and in people from deprived areas. These groups experienced the greatest reductions in rates for new type 2 diabetes diagnosis at the time of the first COVID-19 peak (supplementary figure 1). The reduced rates of type 2 diabetes diagnosis in April were mirrored by reduced rates of new metformin prescriptions in English practices (reduction: 53% (95% CI 51% to 55%; Figure 1b; supplementary table 1). In April, rates of HbA1c testing in England were greatly reduced in people with type 2 diabetes (reduction: 77% (95% CI: 76% to 78%)); Figure 1c; supplementary table 1; with the largest reductions observed in older patients (supplementary figure 2a). Insulin prescribing was reduced by 26% (22% to 30%); (Figure 1d; supplementary table 1). Reductions in rates of new prescribing for both metformin and insulin were
most evident in people aged over 65 years (metformin supplementary figure 3a; insulin: supplementary figure 4a).

Figure 1. Comparison of observed and expected monthly incidence rates for type 2 diabetes in primary care, HbA1c monitoring and new prescriptions for metformin and insulin before and after the first COVID-19 peak in England

![Graphs showing observed and predicted incidence rates for type 2 diabetes diagnoses, new metformin prescriptions, HbA1c testing, and new insulin prescriptions.](image)

Observed
Predicted (with shaded area representing 95% CI)

CPRD Aurum data covering 19,763,481 patients in England
x-axis markers are mid-month; the vertical line denotes 1st March 2020

The reduced rates of diagnosis, new insulin/metformin prescribing and HbA1c testing increased gradually between May and July 2020 though levels remained well below expected rates based on 10-year historical data (figure 1a-d). Overall in English practices, between 1/3/20 and 10/7/20, the rate of diagnosis of type 2 diabetes was reduced by 46% (95% CI: 44% to 49%), metformin prescribing was reduced by 33% (30% to 35%), insulin prescribing fell by 12% (7% to 16%), and HbA1c testing in people with type 2 diabetes was reduced by 48% (46% to 49%); supplementary table 1.
Impact of COVID-19 on mortality in England

In April 2020, mortality rates in people with type 2 diabetes in England were more than 2-fold higher compared to prior trends (mortality rate increase: 110% (95% CI: 102% to 118%); Figure 2a; supplementary table 1). Peaks in mortality were seen particularly in individuals aged over 65 years (supplementary figure 5a). Mortality rates returned to expected levels in people with type 2 diabetes and sub-groups between May and June 2020 (Figure 2a). Overall, between 1/3/20 and 10/7/20, the rate of mortality in people with type 2 diabetes in English practices was increased by 30% (95% CI: 25% to 35%); supplementary table 1.

Figure 2. Comparison of observed and expected monthly mortality rates in people with type 2 diabetes in primary care before and after the first COVID-19 peak, in England (left) and in Northern Ireland, Scotland and Wales (right)

Impacts of COVID-19 in Northern Ireland, Scotland and Wales (CPRD GOLD)

The temporal trends noted above in England (CPRD Aurum practices) were similar overall in Northern Ireland, Scotland and Wales (CPRD GOLD practices) with some notable exceptions. In April 2020, percentage reductions in the incidence of type 2 diabetes, metformin and insulin prescribing in Northern Ireland, Scotland and Wales were similar to reductions in England (supplementary figure 6; supplementary table 2). However, in Northern Ireland, Scotland and Wales (CPRD GOLD), the reduction in the rate of HbA1c testing in people with type 2 diabetes was greater (GOLD vs. Aurum: 84% vs. 77%) and the increase in mortality rate was lower (GOLD vs. Aurum: 66% vs. 110%; supplementary tables 1 and 2).

During the 4½ months between 1/3/20 and 10/7/20, there were smaller percentage reductions in incident type 2 diabetes and new metformin prescribing in practices based in Northern Ireland, Scotland and Wales (CPRD GOLD) compared to in England (GOLD vs. Aurum: incident type 2 diabetes reduced: 37% vs. 46%;...
metformin prescribing reduced: 26% vs. 33%; supplementary tables 1 and 2). Over the same 4½ month period, the overall reduction in HbA1c testing in type 2 diabetes was greater in CPRD GOLD practices based in Northern Ireland, Scotland and Wales (GOLD vs. Aurum: 56% vs. 48%) but the mortality rate increase was lower than in England (GOLD vs. Aurum: 16% vs. 30%; figure 2; supplementary tables 1 and 2).

DISCUSSION

Using primary care data from 13 million people in the UK, and 10-year historical data, we have shown that within the first 4 months of the nationwide ‘lockdown’ in March 2020, the indirect consequences of the COVID-19 pandemic led to: i) a 69-70% reduction in new diagnoses of type 2 diabetes, with older individuals, males, and people from deprived areas experiencing the greatest reduction in diagnosis rates; ii) a 77-84% reduction in HbA1c testing; iii) a reduction in metformin and insulin prescribing, particularly in older people with type 2 diabetes, supporting the reduced rates of diagnosis and monitoring; and iv) a short-term 110% increase in mortality rate in people with type 2 diabetes in England and a 66% increased mortality rate across the rest of the UK.

There is limited prior data on the impact of the COVID-19 pandemic on the diagnosis of type 2 diabetes. A study using primary care data from Salford, UK showed 135 fewer diagnoses of type 2 diabetes than expected between March and May 2020, which amounted to a 49% reduction in activity. ¹⁰ Here we extend these observations by assessing primary care data across the UK and by providing supplementary data on HbA1c testing and mortality. We show that the reduced rate of diagnosis applies to all areas of the UK and not just to deprived areas of the UK such as Salford. To the best of our knowledge, no study has reported the impact of the COVID-19 pandemic on HbA1c monitoring in diabetes, and no study has described national variation in mortality rates in people with type 2 diabetes following the first peak of the pandemic.

Our data have important clinical implications. In early March 2020, GPs were advised to minimise the number of face-to-face contacts they had with their patients, including NHS health-checks. ¹¹ Our data suggests that this reduction of clinical services has led to major reductions in the diagnosis and monitoring of type 2 diabetes. The concomitant reductions in new prescriptions issued for metformin and insulin further support these findings. Type 2 diabetes develops over many years, so it seems unlikely that people’s behaviour during the pandemic has reduced the true incidence of these conditions. Assuming that the true incidence of type 2 diabetes has remained constant from March 2020, our data suggest that, across the UK, the indirect consequences of the pandemic have led to more than 45K missed/delayed diagnoses of type 2 diabetes in the 4½ months between 1/3/20 and 10/7/20. This figure may be an underestimate if sedentary lifestyles and adverse dietary changes during lockdown have increased obesity rates in the general population. ¹² These data are a clinical concern because undiagnosed type 2 diabetes will cause potentially serious long-term complications.

The huge reduction in the rate of HbA1c testing is another important concern for people with type 2 diabetes, because they, and their clinicians, often rely solely on HbA1c data to make decisions about...
treatment. The reduction in new prescriptions for insulin was largely observed in older individuals suggesting this reduction was explained by a failure to intensify therapy in people with poorly controlled long-duration type 2 diabetes. There are already concerns in the UK about clinical inertia in diabetes management, with frequent failures to escalate care when glucose control is poor. These HbA1c data indicate potential further delays in the management of type 2 diabetes that are predicted to cause avoidable diabetes-related long-term complications. A reduced frequency of HbA1c testing in primary care might also contribute to missing people with non-diabetic hyperglycaemia who might benefit from referral to the NHS Diabetes Prevention Programme.

The higher COVID-related death rate in people with diabetes has been well-documented, and our data support these observations. Here, we add to these data by showing national differences in the impact of COVID-19 on mortality rates in people with type 2 diabetes, with higher rates observed in England compared to the rest of the UK. Further research is required to understand how population characteristics including ethnicity, population density and deprivation might explain these differences.

As engagement with health services increases, and hopefully is maintained during the second COVID-19 peak, our data predict a marked increase in presentations with incident type 2 diabetes. Should this occur, then healthcare services will need to manage this backlog, and the expected increase in the severity of diabetes brought about by delayed diagnoses. Older individuals, males and people from deprived backgrounds appear to be most adversely affected by reductions in rates of diagnosis and monitoring of type 2 diabetes. As outpatient diabetes services start to open up, these individuals may be a group to target for early intervention, and in particular, for HbA1c testing and treatment intensification when appropriate. If a second full lockdown occurs, then effective public communications should ensure that patients remain engaged with diabetes services including HbA1c screening and monitoring, and the use of remote consultations.

Our study had several strengths: this is the first UK-wide study reporting the indirect impact of the COVID-19 pandemic on the diagnosis of type 2 diabetes, related prescribing and HbA1c testing in primary care. Our findings in English practices were replicated using data from other parts of the UK. By combining assessments of diabetes coding and prescribing, our data supports the conclusion that reduced rates of diagnoses are genuinely explained by missed diagnoses. Our study has some limitations: First, ethnicity coding is not adequately captured in primary care and therefore we had limited ability to explore ethnicity-related variation in care and outcomes. Future studies will incorporate linked secondary care data that has more complete capture of ethnicity data. Second, it is possible that some diabetes diagnoses may have been made in a hospital setting following an acute presentation and that the related primary care coding had not been updated at the time of our data extraction. While hospital presentation of incident diabetes may have occurred in some instances, it would not explain the reductions in new prescribing for metformin and this potential explanation does not fit with our local experience. In general, people have avoided hospital attendance during the pandemic. For example, one study documented a 23% reduction in emergency admissions in the UK. Finally, although our results and conclusions are relevant to the UK population, generalisability to other healthcare systems may be limited.
In conclusion, we highlight marked reductions in the diagnosis and monitoring of type 2 diabetes as indirect consequences of the COVID-19 pandemic. Over the coming weeks, healthcare services will need to manage this predicted backlog, and the expected increase in the severity of diabetes due to delayed diagnoses. Older people, men and those from deprived backgrounds with type 2 diabetes may be specific groups to target for early HbA1c testing and intervention. Should a second full national lockdown occur, then effective public communications should ensure that patients remain engaged with diabetes services including HbA1c screening and monitoring and the use of remote consultations.

**Contributors**
DMA conceived the original idea. MKR, MJC and AKW helped develop the idea. MJC and AKW performed the analysis and verified the analytical methods. MKR and DMA also reviewed the clinical code sets. NK and NM (primary care clinicians) and LL, HT (secondary care diabetes clinicians) helped interpret the results. MKR wrote the manuscript with input from all authors. All authors critically reviewed and approved the final version.

The lead authors (MJC and AKW: the manuscript’s guarantors) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained. The corresponding author had full access to all of the data and the final responsibility to submit for publication.

**Declaration of interests**
All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years. DMA reports research funding from AbbVie, Almirall, Celgene, Eli Lilly, Novartis, Janssen, UCB and the Leo Foundation outside the submitted work. MKR has received consulting fees and non-promotional lecture fees from Novo Nordisk in relation to cardiovascular disease and diabetes. The company has had no role in influencing the proposed study and is not expected to benefit from this work. Outside the submitted work, MKR reports receiving research funding from Novo Nordisk, consultancy fees from Novo Nordisk and Roche Diabetes Care, and modest owning of shares in GlaxoSmithKline. NM reports honorarium for presentations from Napp Pharmaceuticals, Novo Nordisk, Sanofi, MyLan, Boehringer Ingelheim, Lilly Diabetes, Abbott, Omnia-Med, Takeda UK and AstraZeneca. All other authors declare no competing interests. There are no other relationships or activities that could appear to have influenced the submitted work.

**Data sharing**
All clinical codes used in the study are published on Clinicalcodes.org. Electronic health records are, by definition, considered “sensitive” data in the UK by the Data Protection Act and cannot be shared via public deposition because of information governance restriction in place to protect patient confidentiality. Access to data are available only once approval has been obtained through the individual constituent entities
controlling access to the data. The primary care data can be requested via application to the Clinical Practice Research Datalink (www.cprd.com)

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**Supplementary tables and figures**

**Supplementary table 1:** Comparison of observed and expected monthly incidence rates for type 2 diabetes in primary care, HbA1c monitoring in type 2 diabetes, new prescriptions for metformin and insulin, and deaths in people with type 2 diabetes between 1/3/20 and 10/7/20 and at the COVID-19 peak in April 2020, in England (CPRD Aurum)

|                            | 1st March 2020 to 10th July 2020 | April 2020                      |
|-----------------------------|----------------------------------|---------------------------------|
|                             | Observed Frequency | Expected Frequency (95% CI) | Percentage Deviation (95% CI) | Observed Frequency | Expected Frequency (95% CI) | Percentage Deviation (95% CI) |
| **Incident diagnoses**      | 10,042   | 18,756 (17,808 to 19,754) | -46.4 (-49.1 to -43.6)  | 1228             | 4066 (3861 to 4283)  | -69.7 (-71.3 to -68.1)  |
| **New prescriptions:**      |          |                          |                                 |                   |                                 |                                 |
| Metformin                   | 10,173   | 15,092 (14,442 to 15,772) | -32.5 (-35.4 to -29.5)  | 1489             | 3153 (3017 to 3294)  | -52.7 (-54.7 to -50.6)  |
| Insulin                     | 3841     | 4366 (4152 to 4592)      | -12.0 (-16.3 to -7.4)   | 687              | 930 (884 to 978)     | -26.1 (-29.7 to -22.2)  |
| HbA1c tests                 | 260,624  | 497,273 (482,238 to 512,776) | -47.5 (-49.1 to -45.9)  | 23,392           | 101,019 (97,968 to 104,165) | -76.8 (-77.5 to -76.1)  |
| Deaths                      | 9,180    | 7,074 (6819 to 7339)     | 29.7 (25.0 to 34.6)     | 3326             | 1,585 (1,528 to 1,644) | 109.8 (102.3 to 117.6)  |

Percentage Deviation = 100*(Observed Frequency – Expected Frequency)/(Expected Frequency)
**Supplementary table 2:** Comparison of observed and expected monthly incidence rates for type 2 diabetes in primary care, HbA1c monitoring in type 2 diabetes, new prescriptions for metformin and insulin, and deaths in people with type 2 diabetes between 1/3/20 and 10/7/20 and at the COVID-19 peak in April 2020, in Northern Ireland, Scotland and Wales (CPRD GOLD)

|                                | 1st March 2020 to 10th July 2020                        | April 2020                                      |
|--------------------------------|---------------------------------------------------------|------------------------------------------------|
|                                | Observed Frequency | Expected Frequency | Percentage Deviation | Observed Frequency | Expected Frequency | Percentage Deviation |
|                                | (95% CI)          | (95% CI)           | (95% CI)             | (95% CI)          | (95% CI)           | (95% CI)             |
| Incident diagnoses             | 1753             | 2792 (2629 to 2966) | -37.2 (-40.8 to -33.3) | 207               | 664 (626 to 706)   | -68.8 (-70.6 to -66.9) |
| New prescriptions:             |                  |                    |                      |                  |                    |                      |
| Metformin                      | 1918             | 2604 (2463 to 2752)| -26.3 (-30.3 to -22.1)| 261               | 600 (568 to 634)   | -56.5 (-58.8 to -54.0) |
| Insulin                        | 673              | 762 (714 to 813)   | -11.6 (-17.2 to -5.7) | 139               | 178 (167 to 190)   | -21.9 (-26.8 to -16.7) |
| HbA1c tests                    | 25513            | 58,383 (56,550 to 60,274)| -56.3 (-57.6 to -54.8)| 2112              | 12,811 (12,409 to 13,226)| -83.5 (-84.0 to -82.9) |
| Deaths                         | 1430             | 1229 (1175 to 1285)| 16.3 (11.2 to 21.7)   | 479               | 288 (275 to 301)   | 66.3 (59.1 to 74.1)   |

Percentage Deviation = 100*(Observed Frequency – Expected Frequency)/(Expected Frequency)
Supplementary figures

Supplementary figure 1: Comparison of monthly incidence rates for type 2 diabetes in primary care by age, gender, deprivation level and by region before and after the first COVID-19 peak in England (CPRD Aurum)

(a) T2DM diagnosis by age

(b) T2DM diagnosis by gender

(c) T2DM diagnosis by deprivation

(d) T2DM diagnosis by region
Supplementary figure 2: Comparison of monthly HbA1c testing rates in people with type 2 diabetes in primary care by age, gender, deprivation level and by region before and after the first COVID-19 peak in England (CPRD Aurum)

(a) HbA1c testing rate in people with T2DM by age

(b) HbA1c testing rate in people with T2DM by gender

(c) HbA1c testing rate in people with T2DM by deprivation

(d) HbA1c testing rate in people with T2DM by region
Supplementary figure 3: Comparison of monthly incidence rates for metformin prescribing in primary care by age, gender, deprivation level and by region before and after the first COVID-19 peak in England (CPRD Aurum)

(a) Metformin prescribing by age

(b) Metformin prescribing by gender

(c) Metformin prescribing by deprivation

(d) Metformin prescribing by region
Supplementary figure 4: Comparison of monthly incidence rates for insulin prescribing in primary care by age, gender, deprivation level and by region before and after the first COVID-19 peak in England (CPRD Aurum)

(a) Insulin prescribing by age

(b) Insulin prescribing by gender

(c) Insulin prescribing by deprivation

(d) Insulin prescribing by region
Supplementary figure 5: Comparison of monthly mortality rates in people with type 2 diabetes in primary care by age, gender, deprivation level and by region before and after the first COVID-19 peak in England (CPRD Aurum)

(a) Mortality rate in people with T2DM by age

(b) Mortality rate in people with T2DM by gender

(c) Mortality rate in people with T2DM by deprivation

(d) Mortality rate in people with T2DM by region
**Supplementary figure 6:** Comparison of observed and expected monthly incidence rates for type 2 diabetes in primary care, HbA1c monitoring and new prescriptions for metformin and insulin before and after the first COVID-19 peak in Northern Ireland, Scotland and Wales (CPRD GOLD)

(a) T2DM diagnoses

(b) New metformin prescriptions

(c) HbA1c testing in people with T2DM

(d) New insulin prescriptions

- **Observed**
- **Predicted (with shaded area representing 95% CI)**

*CPRD GOLD* data covering 3,421,100 patients in Northern Ireland, Scotland and Wales.
Supplementary figure 7: Flow diagram of the cohort from CPRD Aurum

1. Permanent registrations only.
2. Acceptability defined by CPRD as meeting certain quality standards.
3. Study period: 1<sup>st</sup> January 2010 to 10<sup>th</sup> July 2020.
4. Reasons: (a) registration ended prior to study period due to death or migration from practice (n = 12,440,573); (b) registration end date defined on or prior to registration start date (n = 21,315); (c) aged under 5 on study period end (n = 757,327).
5. Study population used to model trends (between January 2010 and February 2020) and/or compare expected and observed rates (between March and July 2020).
6. Only contributed to modelling trends.
7. Study cohort.

Patients in August 2020 version of CPRD Aurum database (n = 44,231,694)

- With records acceptable for research purposes (n = 36,029,818)
  - Registered in England (n = 35,866,243)
    - With required demographic information (n = 35,865,163)
      - Registered and eligible for at least 1 day during study period (n = 22,645,948)
        - At least 1 year of prior follow up (n = 19,763,481)
          - Registered for at least one day during 1<sup>st</sup> March to 10<sup>th</sup> July 2020 (n = 11,178,495)
            - With a diagnosis of type 2 diabetes (n = 605,945)

- Without records acceptable for research purposes (n = 8,201,876)
  - Registered in Northern Ireland, Scotland or Wales (n = 163,575)
    - Missing required demographic information (n = 1080)
  - Not registered and/or eligible during study period (n = 13,219,215)
    - Less than 1 year of prior follow up (n = 2,882,467)
  - Registration ended before 1<sup>st</sup> March 2020 (n = 8,584,986)
Supplementary figure 8: Flow diagram of the cohort from CPRD GOLD

1. Permanent registrations only.
2. Acceptability defined by CPRD as meeting certain quality standards.
3. Study period: 1st January 2010 to 10th July 2020.
4. Reasons: (a) registration ended prior to study period due to death or migration from practice (n = 2,159,261); (b) registration end date defined on or prior to registration start date (n = 146,723); (c) aged under 5 on study period end (n = 121,328).
5. Study population used to model trends (between January 2010 and February 2020) and/or compare expected and observed rates (between March and July 2020).
6. Only contributed to modelling trends.
7. Study cohort.