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ORIGINAL PAPER

Non-communicable diseases, COVID-19 and labour market outcomes

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Abstract
The COVID-19 pandemic affected people with Non-Communicable Diseases (NCDs) in multiple ways. However, limited attention has been paid to its impact on labour outcomes for individuals with pre-existing NCDs. Given the heightened vulnerability of individuals with NCDs to COVID-19, the pandemic and related lockdown measures may have disproportionately influenced their employment prospects. Our study investigates the effects of the COVID-19 pandemic on the employment status and work hours of individuals with NCDs. We use data from the Understanding Society COVID-19 study in the UK, supplemented with main-stage Understanding Society surveys. We apply a difference-in-difference approach to estimate the pandemic's impact on labour market outcomes over time. Our results indicate that COVID-19 significantly reduced both the likelihood of employment and working hours among individuals with NCDs relative to those without. These effects varied by age, gender, sector of employment (key workers vs. non-key workers), and type of NCDs. We further examine potential causes for the reduction in employment and working hours, and find that while the pandemic did not exacerbate existing health conditions among people with NCDs, their reduced labour market participation was largely driven by increased vulnerability to infection, the impact of long COVID, and the effects of public health interventions. Our study provides deeper insights into the post-pandemic contraction of the UK labour market, suggesting that the combined effects of NCDs and COVID-19 have contributed to a decline in workforce participation.

Keywords Non-Communicable Diseases(NCDs) · COVID-19 · Employment likeli-hood · Work hours

Introduction

Non-communicable diseases (NCDs), also known as chronic diseases, are long-term health conditions that arise from a combination of genetic, physiological, environmental, and behavioural factors. The most common NCDs include cardiovascular diseases, diabetes, hypertension, chronic respiratory diseases, and cancer. NCDs account for 74% of global deaths and a similar share of premature adult mortality [1]. Beyond their health consequences, NCDs impose a substantial economic burden at both the micro and macro levels. The total cost of NCDs between 2011 and 2030 has been estimated at US$47 trillion [2], though these estimates may now be outdated given the disproportionate effects of the COVID-19 pandemic on individuals with NCDs.

The COVID-19 outbreak, which began in December 2019, rapidly spread across the globe, placing unprecedented pressure on health systems and disrupting social and economic life worldwide. The World Health Organization (WHO) declared the outbreak a pandemic in March 2020. COVID-19 caused millions of deaths globally and left many more with long-term health complications [3]. It challenged public health systems in disease control and crisis management, while lockdown measures implemented across countries halted many economic activities and contributed to a severe global economic downturn.

The pandemic affected individuals with NCDs through several channels. First, people with NCDs were at greater risk of getting infected with COVID-19, and once infected, they had a higher probability of developing severe health complications [4–6]. Mortality rates due to COVID-19

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were substantially higher among individuals with NCDs than among healthy individuals [7–10]. Second, the unprecedented strain on health systems hindered access to healthcare for individuals with NCDs, disrupting treatment, disease management, and screening for new NCD cases [11–17]. Access to timely diagnosis, treatment, and continuity of care is crucial for preventing complications and premature death among people with NCDs [18]. Third, COVID-19-related lockdowns, self-isolation, and travel restrictions created an unfavourable environment for maintaining healthy behaviours, increasing exposure to several behavioural risk factors such as unhealthy diets, alcohol use, physical inactivity, and stress, likely exacerbated existing NCDs and triggered new health issues [13, 19, 20], especially deteriorating mental health [21–24].

Despite the growing literature on the relationship between COVID-19 and NCDs, relatively little attention has been paid to the pandemic's impact on labour market outcomes among individuals with pre-existing NCDs. The pandemic led to widespread economic shutdowns and adversely affected labour market performance [25–28]. For instance, during the first COVID-19 lockdown in the UK, employment declined sharply, unemployment and economic inactivity rose, and working hours fell to their lowest level since 1994 [29]. Given the elevated health risks faced by individuals with NCDs and the additional self-isolation measures many adopted, the pandemic and related restrictions may have disproportionately affected their employment outcomes. Given the rising prevalence of NCDs among the working-age population [30–32], understanding the impact on their labour market outcomes warrants further investigation.

In this paper, we analyse the effects of the COVID-19 pandemic on the labour market outcomes of individuals with NCDs in the UK.[1] Specifically, we examine the pandemic's impact on (1) the likelihood of employment (extensive margin) and (2) working hours (intensive margin). We use data from the UK Household Longitudinal Study (Understanding Society) and the COVID-19 study, a longitudinal dataset capturing the experiences and responses of the UK population during the pandemic. We employ a difference-in-differences approach to estimate the average treatment effect of the pandemic on the labour market outcomes of individuals with NCDs.

Our findings indicate that COVID-19 reduced the labour supply of individuals with NCDs, both at the extensive and intensive margins. These effects are heterogeneous across population subgroups defined by age, occupation type (key vs. non-key workers) and riskiness of the NCD condition. We also find variation in effects over time: the decline in working hours among people with NCDs persisted as the pandemic progressed, with a substantial reduction evident during the later stages compared to pre-pandemic levels. We explore potential explanations for this decline and find that neither deteriorating general nor mental health fully accounts for the decrease in labour supply. Instead, increased vulnerability to the virus, the long-term effects of COVID-19, and public health interventions appear to be key contributing factors.

The remainder of the paper is structured as follows. Section 2 reviews the related literature on the impact of COVID-19 on labour outcomes and their heterogeneity across population subgroups. Section 3 describes the data, Sect. 4 outlines the empirical strategy, Sect. 5 presents the results, and Sect. 6 concludes.

Heterogeneous effect of COVID-19 on labour market outcomes

COVID-19 affected the labour market outcomes, including employment, work hours, earnings, and working arrangements, in many countries [25, 29, 33, 34]. Countries hardest hit by the pandemic experience the most severe labour market consequences [35]. The negative impacts were concentrated in certain sectors: employees in hospitality, non-essential retail, and travel were particularly affected [25, 36], whereas jobs in essential sectors were less exposed even during the pandemic's peak [37]. Similarly, self-employed and informally employed workers suffered more than those in formal employment [26, 38].

Evidence on gender differences in labour market impacts is mixed. Some studies find that women were more adversely affected than men in both employment probability and working hours [38, 39], whereas others report no gender divergence during the pandemic [40] [41]. find no gender differences in employment loss or furlough incidence, although women experienced slightly smaller reductions in hours and earnings overall. The negative effects were more pronounced among women with children, reflecting their greater childcare responsibilities during lockdowns [26]. This pattern contrasts with typical recessions, in which women are generally less affected than men [42].

Labour market impacts also varied by age. Young workers experienced significant job losses in the early stages of the pandemic [27, 38], largely because their employment was concentrated in sectors heavily affected by lockdowns [25]. However, youth employment largely recovered to

[1] The UK experienced several stages of the COVID-19 pandemic, especially acute during the first and second waves, with several lockdown measures from March 2020 to March 2021, creating severe disruptions to ordinary life. The UK ranks among the first ten countries in the world worst hit by the pandemic.

pre-pandemic levels. Older workers also faced employment declines at the pandemic's onset, but recovery was slower, in part due to higher retirement rates [29, 43].

The pandemic exacerbated pre-existing inequalities for ethnic minorities and disadvantaged groups, with unemployment rates higher than those for the ethnic majority [43, 44]. Similarly, employment gaps widened between disabled and non-disabled workers [29]. Educational attainment was another determinant: workers with lower education levels were disproportionately affected [34, 45].

Some evidence suggests that the labour market impacts of COVID-19 were temporary or overstated [40]. show that the widening of inequalities in the first pandemic wave in the UK was subsequently reversed, and that declines in working hours largely recovered in later stages [46]. find that published studies on job loss and unemployment during COVID-19 exhibit upward publication bias, and after correcting for this, the overall labour market impact appears modest.

Overall, this literature highlights that COVID-19 affected labour market outcomes heterogeneously, depending on workers' demographic and socio-economic characteristics and their sector of employment. However, the pandemic's impact on labour market outcomes of individuals with NCDs has received little attention. This paper aims to fill this gap in the literature.

Data

We use data from the UK Household Longitudinal Study (UKHLS, also known as the Understanding Society) and the Understanding Society COVID-19 Study. Understanding Society is a nationally representative longitudinal survey of UK households that collects data from individuals aged 16 and over. The COVID-19 Study is a supplementary panel survey designed to capture the short-and medium-term impacts of the COVID-19 pandemic on the UK population. It comprises nine waves, beginning in April 2020, followed by monthly surveys until July 2020. From September 2020 onwards, data were collected bi-monthly until March 2021, with a final wave in September 2021 [47].[2]

Our analysis includes all nine COVID-19 waves and all individuals who participated in at least one of them. Pre-pandemic information on individuals was obtained from the Understanding Society mainstage surveys (waves 5 to 10).[3] All individuals in the COVID-19 study have participated in at least one pre-pandemic mainstage UKHLS survey. The analytical sample is restricted to individuals under 65 years of age to exclude those likely affected by default retirement. The final sample comprises 15,369 individuals within this age range.

The Understanding Society survey provides data on individuals' long-term health conditions, which we use to identify NCDs. We classify individuals as having an NCD if they report at least one long-term health condition.[4] Following the World Health Organization (WHO) classification [48], we further distinguish a subset of risky NCDs (RNCDs)—conditions associated with a higher likelihood of severe COVID-19-related illness. These include respiratory diseases, cardiovascular diseases, cancer, diabetes, and obesity.

Table 1. presents descriptive statistics for the full sample and by NCD status. At the onset of the pandemic, 38% of individuals in our sample had at least one NCD. The average age of respondents is 43 years, 60% are female, and 84% identify as White. Approximately one-third (33%) hold a college-level education or higher, and 68% are married or in a civil partnership. Individuals with NCDs tend to be older, less educated, and more likely to be female and of White ethnicity compared with those without NCDs. Overall, 76% of respondents were engaged in paid work at the time of the survey, although this share is lower among individuals with NCDs. Among all participants, 67% were employed only, and 9% were self-employed only. The average weekly working hours among those in paid employment is 32.4 h, with individuals without NCDs working approximately 1.06 h more per week than those with NCDs.

Methods

This study examines the effect of the COVID-19 pandemic on the labour market outcomes of individuals with NCDs. To identify this effect, we adopt a quasi-experimental design in which individuals with NCDs constitute the treatment group, while those without NCDs form the control group. The onset of the COVID-19 pandemic in early 2020 represents an exogenous shock that affected all individuals but with heterogeneous intensity across health status

[2] The COVID-19 study waves were collected in April 2020, May 2020, June 2020, July 2020, September 2020, November 2020, January 2021, March 2021, and September 2021.

[3] Wave 5 of the US mainstage survey was conducted in Jan 2013-Jun 2015, Wave 6 in Jan 2014-May 2016, Wave 7 in Jan 2015-May 2017, Wave 8 in Jan 2016-May 2018, Wave 9 in Jan 2017-May 2019 and wave 10 in Jan 2018-May 2020.

[4] The long-term health conditions include asthma, arthritis, congestive heart failure, coronary heart disease, angina, heart attack, stroke, emphysema, chronic bronchitis, liver conditions, cancer, diabetes, epilepsy, high blood pressure, multiple sclerosis, chronic obstructive pulmonary disease (COPD), emotional or psychiatric problems, hyperthyroidism, chronic kidney disease, brain and nerve conditions, and overweight.

Table 1 Sample characteristics by NCD status

Variable	All	NCDs	Non-NCDs
Age (years)	42.9	47.8	40.7
	(13.6)	(12.2)	(13.2)
Female	0.599	0.622	0.586
	(0.490)	(0.485)	(0.493)
White ethnicity	0.837	0.863	0.822
	(0.370)	(0.344)	(0.382)
Marital status:			
Single/never married	0.234	0.178	0.269
Married/Civil partnership	(0.423)	(0.382)	(0.443)
	0.679	0.703	0.663
Widowed	(0.467)	(0.457)	(0.473)
	0.012	0.017	0.008
Separated/Divorced	(0.107)	(0.128)	(0.092)
	0.072	0.099	0.056
	(0.259)	(0.298)	(0.230)
Education:			
Less than OL	0.165	0.186	0.152
O/L to A/L	(0.371)	(0.389)	(0.359)
	0.304	0.276	0.321
A/L to College	(0.460)	(0.447)	(0.467)
	0.101	0.111	0.095
College and above	(0.301)	(0.314)	(0.293)
	0.332	0.318	0.341
Having school-age children	(0.471)	(0.466)	(0.474)
	0.177	0.164	0.184
Engage in paid work	(0.381)	(0.370)	(0.388)
	0.762	0.721	0.787
(employed/self-employed/both)	(0.426)	(0.448)	(0.410)
Employed only	0.670	0.627	0.697
Self-employed only	(0.470)	(0.484)	(0.460)
	0.092	0.094	0.090
Weekly work hours	(0.289)	(0.292)	(0.286)
	32.40	31.74	32.80
NCDs	(0.113)	(0.190)	(0.141)
	0.380	-	-
	(0.485)		
Risky NCDs	0.205	0.538	-
Other NCDs	(0.403)	(0.499)	-
	0.176	0.462	
Number of respondents	(0.31)	(0.499)	9,462
	15,269	5,807	

The table shows the mean values of sample characteristics. The sample consists of all individuals aged below 65 years who are included in at least one Covid survey. All figures represent pre-covid sample characteristics obtained from waves 9 and 10 of UKHLS

groups and over time. Hence, we employ a difference-in-differences (DiD) approach using the following parametric specification, which measures the average treatment effect of the pandemic on labour outcomes among individuals with NCDs relative to those without:

$$Y_{it} = \beta_0 + \beta_1 Covid_t + \beta_2 NCD_{it} + \beta_3 (Covid_t * NCD_{it}) + \beta_4 Time_t + \delta Z_{it} + \epsilon_{it} \quad (1)$$

where *Yit* is our labour outcome variables of interest: probability of employment and, conditional on employment, number of weekly hours worked. *Covidt* is an indicator variable that takes value one for the post-Covid period (from April 2020 onwards) and zero before that. *NCDit* is a dummy variable denoting whether the individual *i* has any NCD at the time *t*. $\beta 3$, corresponding to the interaction of *Covidt* and *NCDit*, is our coefficient of interest as it identifies the average treatment on treated individuals (ATT of those with NCDs) that exists after the onset of the COVID-19 pandemic. *Timet* captures the time trend and *Zit* is the vector of control variables, consisting of gender, age, race, education, marital status and having school-age children.[5] ϵit is the unobserved error term. In all results presented, we show the effects for the whole sample, and examine differences by employment status: employed and self-employed.

$\beta 3$ only provides the average effect over the entire period after the onset of the pandemic. However, heterogeneous effects could exist according to the progress and severity of the pandemic in subsequent waves. Therefore, we use a panel event study and obtain estimates of the impact of each wave post-COVID-19 on labour outcomes. Our specification is modified to follow this structure:

$$Y_{it} = \alpha_0 + \sum_{k=1}^{13} Wave_{it} * \alpha_k + \alpha_2 NCD_{it} + \sum_{w=1}^{13} (Wave_{it} * NCD_{it}) * \alpha_w + \delta Z_{it} + \epsilon_{it} \quad (2)$$

where *Yit* and *NCDit* are defined as above, and *Waveit* is an indicator variable for each wave of COVID-19 surveys (from 1 to 9), and pre-covid waves of US mainstage survey (wave 7 to wave 9), taking as the reference period wave 10 of mainstage survey. This specification allows us to compare the differential effect of each COVID period with the pre-COVID period. The coefficients of the interaction between Wave and NCD, αw are the ATTs, our parameters of interest. Estimates are obtained using linear regression models.

The validity of the DiD specification relies on two key assumptions. The first is the parallel trends assumption, which states that, in the absence of the COVID-19 pandemic, the labour market outcomes of individuals with and without NCDs would have evolved along similar trajectories. Figure 1 plots the mean probability of employment and average weekly working hours for both groups during the pre- and post-pandemic periods. As shown, individuals with NCDs consistently exhibited lower employment probabilities and shorter working hours than those without NCDs, yet the trends appear approximately parallel before the onset of the pandemic. Following the outbreak, the gap between the two groups widened—particularly with respect to working hours. In addition to the visual inspection, we formally

[5] Parents who had school children spent considerable number of hours on homeschooling during COVID-19 [49].

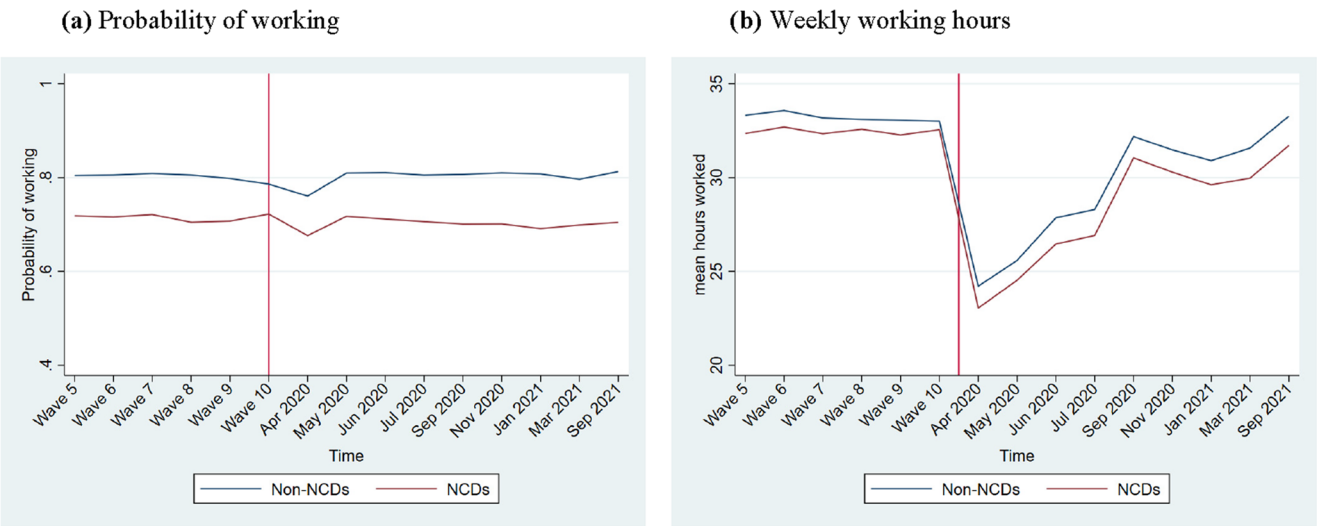

Fig. 1 Probability of working and weekly working hours of individuals with NCDs and others

Table 2 Overall impact of COVID-19 on labour market outcomes

	Probability of working			Weekly hours worked		
	All	Employed	Self-employed	All	Employed	Self-employed
	(1)	(2)	(3)	(4)	(5)	(6)
ATT	−0.0446***	−0.0341***	−0.0103***	−1.3635***	−1.2598***	−2.4483***
	(0.0030)	(0.0032)	(0.0018)	(0.1422)	(0.1448)	(0.5303)

Each estimated coefficient corresponds to separate DID regression, one for each labour outcome and group of interest. All models were estimated controlling for time, age, gender, ethnicity, education, marital status and having school-age children

assess the parallel trends assumption using the approach proposed by [50], and the results are reported in the sensitivity analysis section. The second assumption required for the DiD framework is the absence of anticipation effects. This condition is plausibly satisfied, as the COVID-19 pandemic was an exogenous and unforeseen event that emerged abruptly in early 2020.

Results

This section presents the results of our analysis examining the impact of the COVID-19 pandemic on the labour market outcomes of individuals with NCDs. Throughout the analysis, we estimate effects across three employment categories: all working individuals, employees, and the self-employed.

We proceed in several steps. First, we estimate the overall impact of COVID-19 on the probability of working (extensive margin) and on weekly working hours (intensive margin). Second, we explore heterogeneous treatment effects across different post-COVID periods. Third, we examine heterogeneity across key subgroups of the population. We then conduct sensitivity analyses to assess potential violations of the parallel trends assumption. Finally, we investigate possible mechanisms underlying the observed deterioration in labour market outcomes among individuals with NCDs.

Labour market outcomes for NCD individuals after COVID-19

Estimates of the overall impact of COVID-19 obtained using the DiD framework are presented in Table 2, and the complete regression results are reported in Table A1. The first three columns of Table 2 show the effects on the extensive margin (probability of working), while the last three columns present the effects on the intensive margin (weekly working hours).

The estimates indicate that the pandemic adversely affected the labour market outcomes of individuals with NCDs. The probability of working was 4% points (pp) lower for individuals with NCDs compared with those without NCDs as a result of the pandemic. This effect was primarily driven by employees, whose probability of working was 3 pp lower than that of non-NCD employees. The estimated effect among the self-employed was smaller in magnitude, corresponding to a 1 pp decline in the probability of working. Conditional on being engaged in work, individuals with NCDs experienced a larger reduction in working hours. On average, their weekly working hours declined by 1.4 h more than those of individuals without NCDs. The reduction was particularly pronounced among the self-employed, who worked 2.4 fewer hours per week compared with a 1.3-hour reduction among employed individuals with NCDs.

Heterogeneous treatment effects of COVID-19

Impact on the extensive margin

To account for potential time-varying effects of the pandemic on the labour market outcomes of individuals with NCDs, we estimated a linear probability model as specified in Eq. 2. The estimated ATTs, which capture the impact of COVID-19 on the probability of working for individuals with NCDs at different points in time, are presented in Fig. 2. The complete set of regression coefficients is reported in Table A2 in the Appendix.

The results indicate that the probability of working among individuals with NCDs declined progressively as the pandemic unfolded. This reduction was mainly driven by a fall in the likelihood of being employed. Specifically, in April 2020—the onset of the pandemic—the probability of employment among individuals with NCDs was approximately 2.2% points (pp) lower than that of individuals without NCDs. This negative effect persisted until January 2021, when the UK experienced the peak of the second wave of COVID-19. A slight recovery was observed in March 2021, followed by a further decline by September 2021.

For the self-employed, the estimated effects are smaller in magnitude. Their probability of working was about 1 pp lower in the early stages of the pandemic, with a modest recovery toward the end of the study period, remaining approximately 0.4 pp below that of non-NCD counterparts. Overall, individuals with NCDs in self-employment also experienced a reduction in work probability, albeit less pronounced than among employees.

Figure 2 also allows for an assessment of pre-treatment trends. The estimated coefficients for interaction terms in waves 8 and 9 are statistically insignificant, suggesting no systematic differences in trends immediately before the pandemic. However, the coefficients for waves 5–7 are statistically significant, indicating potential deviations from strict parallel trends. As such deviations may pose a risk to the validity of the DiD estimates, we conduct a robustness check using the sensitivity analysis proposed by [50], which evaluates the extent to which the estimated effects change under possible violations of the parallel trends assumption.

Impact on the intensive margin

We next examine how the impact of the pandemic on weekly working hours evolved over time by estimating a DiD model as specified in Eq. 2. The estimated coefficients for the interaction terms on individuals' weekly working hours (conditional on being in employment) are presented in Fig. 3, and the full set of regression results is reported in Appendix Table A2.

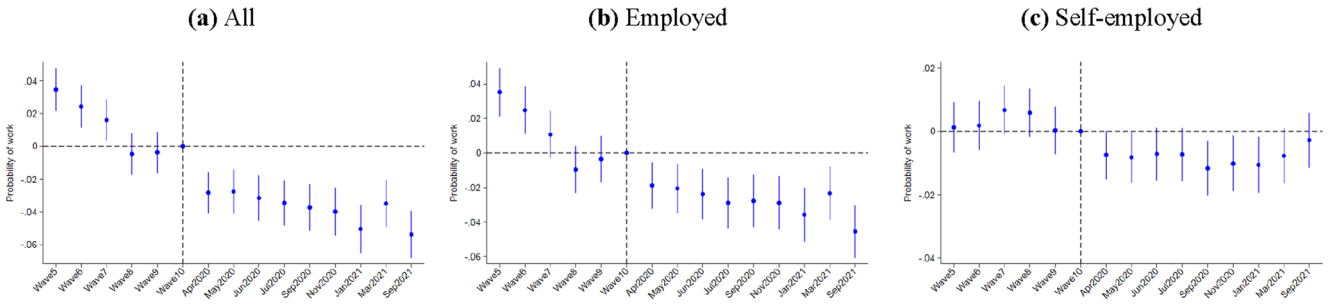

Fig. 2 Estimated effects of COVID-19 on the probability of work. *Notes:* Figure shows the DiD coefficients of the linear probability models on the probability of work estimated for Fig. (**a**) all respondents who work (either employed, self-employed or both); Fig. (**b**) those employed; (**c**) self-employed individuals

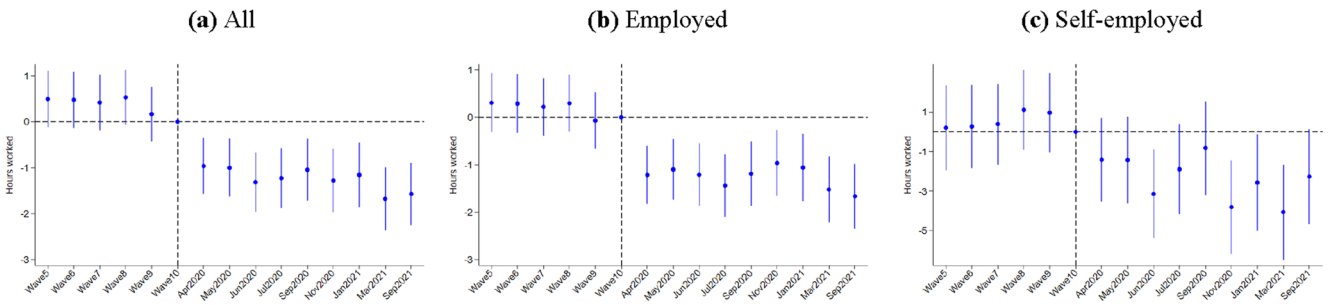

Fig. 3 Estimated effects of COVID-19 on weekly hours worked. *Notes:* The regressions are conditional on employment status. Figure shows the DiD coefficients of the regressions on weekly working hours estimated for: Fig (**a**) all individuals; Fig. (**b**) those employed; (**c**) self employed individuals

The results show that the pandemic led to a substantial reduction in the number of weekly hours worked by individuals with NCDs compared to those without NCDs. The magnitude of this reduction varied across time and employment categories. Panel (a) of Fig. 3 illustrates the results for all individuals, irrespective of employment type, indicating that individuals with NCDs worked on average one hour less per week than their non-NCD counterparts in April 2020. This reduction deepened as the pandemic progressed, reaching approximately 1.6 fewer hours per week by September 2021.

The reduction in weekly working hours appears to partially mirror the severity of the pandemic, particularly for employed individuals. For NCD individuals, weekly hours declined sharply at the start of the pandemic, with the reduction intensifying between May and July 2020. A slight recovery occurred between September and November 2020, coinciding with a modest economic rebound following the first wave. Following the second wave, after January 2021, the negative impact on weekly hours intensified, particularly in March and September 2021. For self-employed individuals with NCDs, the decline in weekly hours was generally larger and exhibited greater fluctuations over time. The largest reduction occurred in March 2021, when self-employed NCD individuals worked 3.8 fewer hours per week than their non-NCD counterparts. Figure 3 also shows that the pre-pandemic interaction coefficients are statistically insignificant, supporting the validity of the parallel trends assumption.

Sub-sample analysis

We conducted several sub-sample analyses to gain further insights into the differential effects of COVID-19 across population groups. Using the same DiD specification as in Eq. 2, we restricted the sample by age groups, gender, work classifications, and NCD types. The full set of estimated coefficients for these regressions, including all controls, is presented in Tables A3 and A4 in the Appendix.

Our first sub-sample analysis examines individuals aged below 55 and those aged 55 to 65. We estimate the effects on both the extensive and intensive margins, with the coefficients presented in Fig. 4. Graphs (a) and (b) show the estimated impact on the probability of work, while Graphs (c) and (d) display the effects on weekly work hours. The reduction in the probability of working is greater for those under 55, with a decrease of around 4 pp in April 2020. For individuals aged 55 to 65, the effect is mostly insignificant,

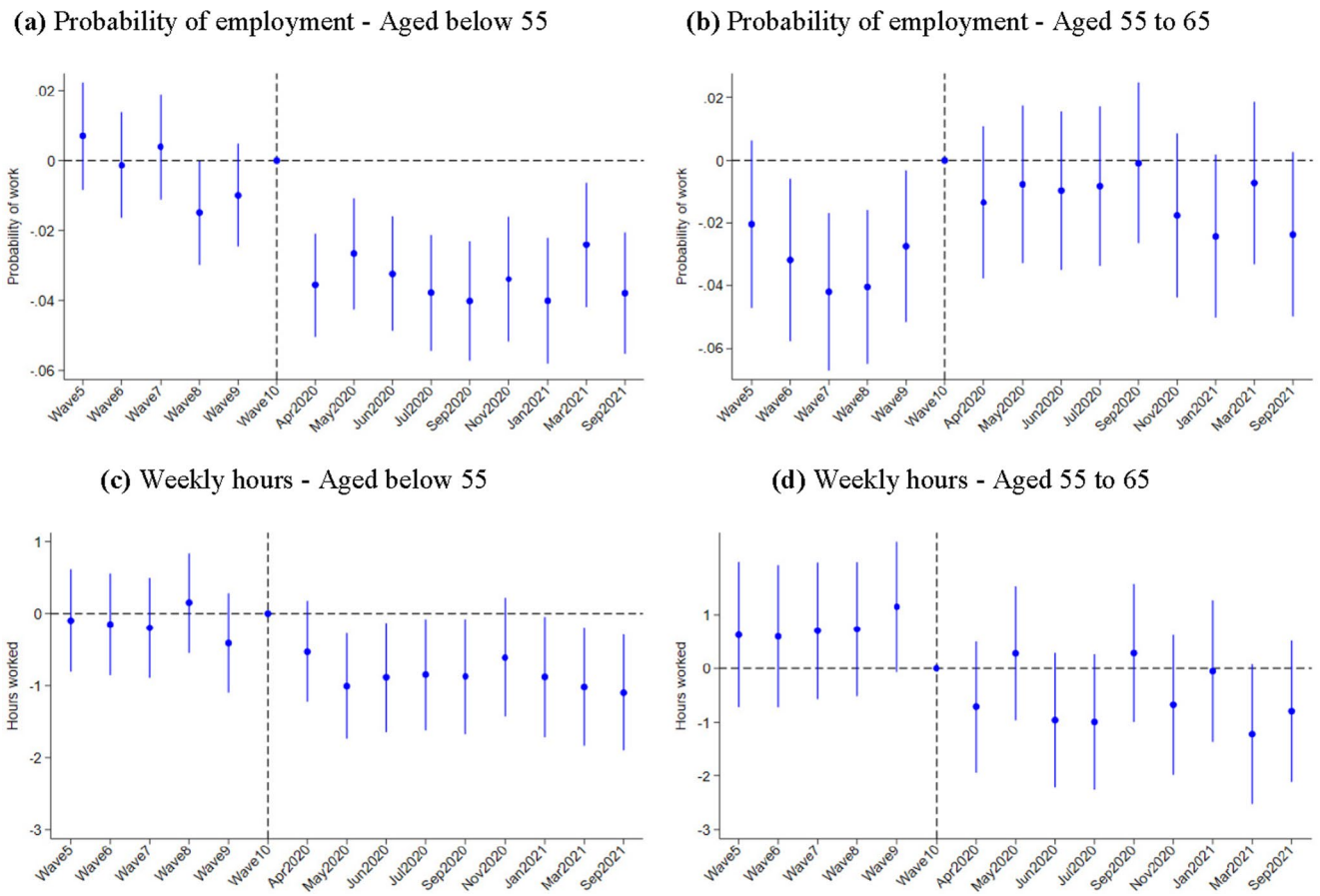

Fig. 4 Estimated effect of COVID-19 on NCD individuals by age groups. *Notes:* DiD coefficients for the regressions on the probability of working and weekly work hours for individuals in age groups < 55 and 55 to 65

except for a roughly 2 pp reduction in January and September 2021. The patterns for weekly work hours are similar: those under 55 experienced a reduction fluctuating around 1 h, while for the 55–65 age group, work hour reductions are more erratic over time and largely statistically insignificant.

The next sub-sample analysis examines gender differences, with results presented in Fig. 5. At the start of the pandemic, the impact on the probability of work was higher for males with NCDs than for females. In April 2020, the probability of working decreased by 4 pp for males with NCDs, compared to a 2.6 pp point reduction for females, relative to their non-NCD counterparts. The initial decline in work probability for females persisted as the pandemic progressed, while it slightly improved for males before declining again. During the second wave of the pandemic in January 2021, males with NCDs experienced the largest reduction in work probability, at 6 pp.

The pattern for weekly work hours differs slightly between genders. Males with NCDs experienced a larger reduction in hours than females, particularly during the early stages of the pandemic. In April 2020, females with NCDs worked 0.8 h less than their non-NCD counterparts, whereas males with NCDs worked 1.4 h less. Between June and September 2020, the negative impact on females' work hours decreased, while it increased for males. From September 2020 to January 2021, the reduction in females' work hours worsened, whereas for males it initially improved before declining again.

We further examine whether the effects of the pandemic vary according to NCD type. While our main analysis uses a broad classification of NCDs encompassing all reported long-term health conditions, we now differentiate between individuals with riskier NCDs (RNCDs), which are associated with more severe outcomes if infected with COVID-19, and those with non-risky NCDs (referred to here as "other NCDs"). Figure 6 presents the estimated coefficients, revealing notable differences in work probabilities and weekly work hours between these two groups.

At the onset of the pandemic, the probability of working for individuals with RNCDs declined by 4 pp, whereas the impact on those with other NCDs was insignificant. For individuals with RNCDs, this reduction persisted over time with minor fluctuations, reaching a 6 pp gap by September 2021 compared to non-NCD individuals. In contrast, a significant decline in work probability for other NCDs only

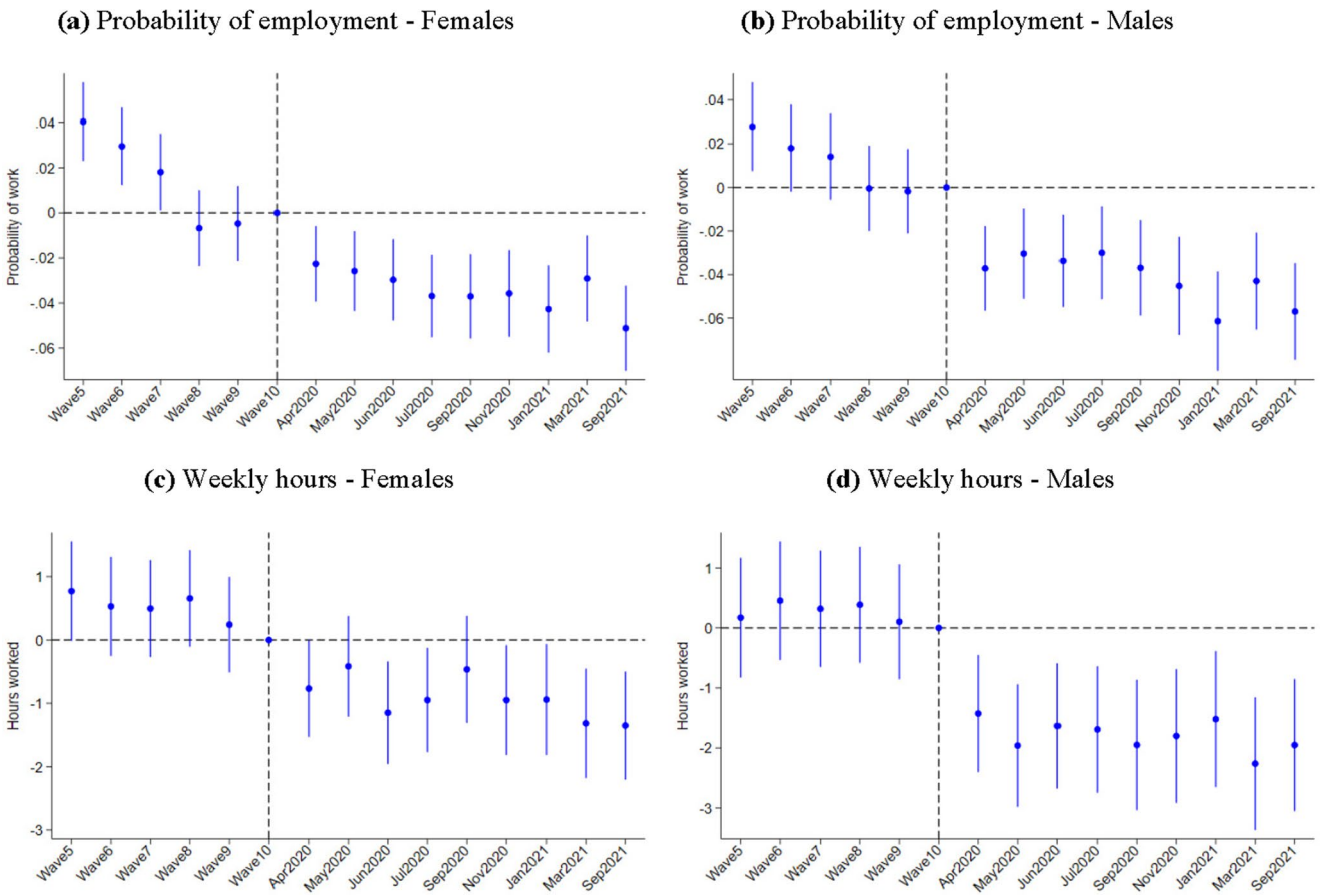

Fig. 5 Estimated effect of COVID-19 on NCD individuals by gender. *Notes:* DiD coefficients for the regressions on the probability of working and weekly work hours for females and males

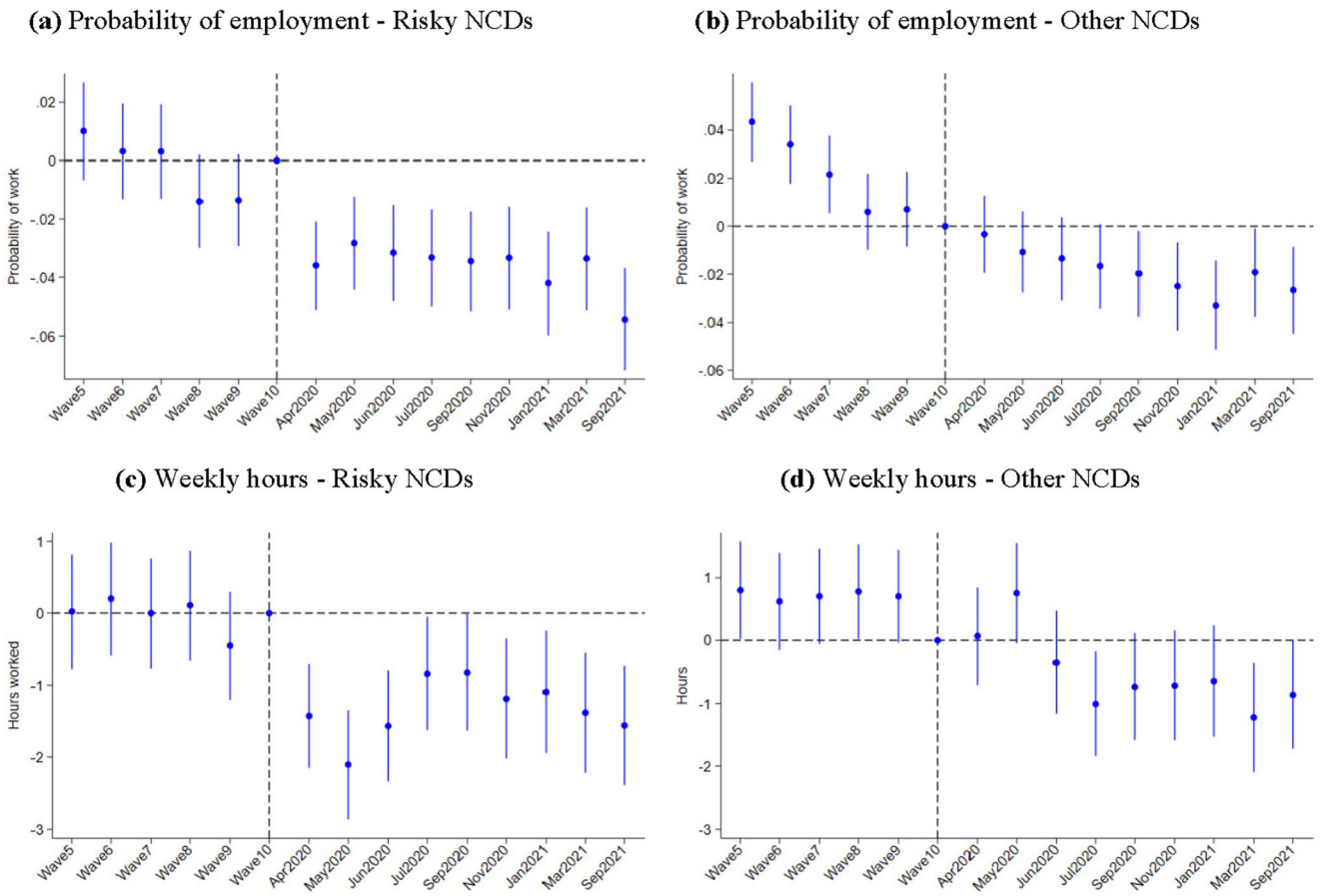

Fig. 6 Estimated effect of COVID-19 on NCD individuals by NCD type. *Notes:* DiD coefficients for the regressions on the probability of working and weekly work hours for risky and non-risky NCDs

emerged after July 2020. Weekly work hours show a similar divergence. The negative effect of the pandemic was more pronounced for individuals with RNCDs than for those with other NCDs in the early stages. In May 2020, individuals with RNCDs experienced a reduction of 2 h per week, while those with other NCDs worked 0.7 h more than their non-NCD counterparts. Between May and July 2020, the reduction in hours for RNCD individuals decreased slightly, whereas it increased for individuals with other NCDs. From September 2020 onward, the negative impact intensified for RNCD individuals, while for other NCDs the effect remained largely insignificant, except for a decline in March 2021.

Since keyworkers played a critical role in the labour market during the pandemic, we examine the heterogeneous effects of COVID-19 on individuals with NCDs classified as keyworkers[6] compared to non-keyworkers. We focus on the intensive margin, with coefficients presented in Fig. 7. At the onset of COVID-19, the pandemic-related reduction in weekly work hours for individuals with NCDs was significantly larger for keyworkers than for non-keyworkers. Keyworkers with NCDs lost approximately 1.7 h per week in April 2020, compared to an insignificant 0.6-hour reduction for non-keyworkers. The negative impact on keyworkers remained relatively stable throughout the pandemic, declining slightly to about 1.5 h per week by September 2021. In contrast, non-keyworkers with NCDs experienced a larger and continuous reduction in weekly work hours, reaching approximately 2.5 h less per week by March 2021 compared to individuals without NCDs.

Sensitivity analysis

Our analysis of heterogeneous effects in Sect. 5.2 indicates that there are no differences in pre-trends between NCD and non-NCD individuals for weekly work hours, as shown in Fig. 3. This also holds for the probability of employment in

[6] During the pandemic, the UK Government identified several employment categories as keyworkers, including health and social care, education and childcare, utilities and communication, food and necessary goods, transport, key public services, public safety and national security, and national and local government. Pre-COVID identification of these categories in earlier waves is complex, so we assume an individual's work category at the start of the pandemic is the same as in wave 10 of the UKHLS mainstage survey. Accordingly, we do not derive pre-COVID trends and estimate post-COVID coefficients only.

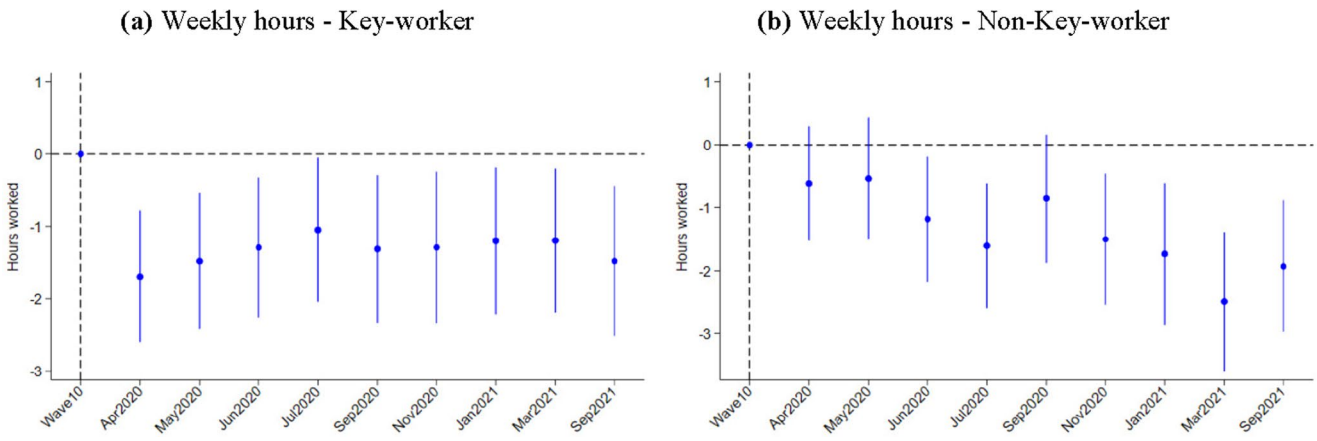

Fig. 7 Estimated effect of COVID-19 on NCD individuals: Key-worker vs. non Key-worker. *Notes:* DiD coefficients for the regressions on the weekly work hours for key-workers versus non-key-workers

the periods immediately preceding the pandemic. However, in waves 5 to 7, there appears to be a divergence in trends between the two groups. A key concern in this context is that unobserved, individual-specific shocks may have affected the labour market outcomes of individuals with NCDs differently from those without NCDs prior to the COVID-19 pandemic, and it is unclear whether such differential trends persist post-COVID.

To explore this further, we conduct a sensitivity analysis to test for violations of parallel trends between consecutive periods in our DiD framework, using the approach developed by [50]. We compute confidence sets for the average treatment effect on the treated (ATT), adjusting for the magnitude of any parallel trend violations post-pandemic relative to pre-pandemic trends, as captured by $\bar{M}$. Specifically, we test the assumption that individual-specific shocks affecting NCD individuals post-treatment are no larger than those affecting them before the pandemic. To assess the robustness of our results, we consider different values for $\bar{M}$, with $\bar{M} = 1$ representing a scenario where the post-pandemic violation of parallel trends is constrained to be no greater than the largest pre-pandemic violation.

Figure 8 presents robust confidence sets for the treatment effect over the average post-pandemic period using different values of $\bar{M}$. The results indicate that the estimates are generally robust to potential violations of the parallel trends. The figure also identifies the breakdown point at which we can no longer reject the null hypothesis of no effect. This breakdown value is $\bar{M} = 1$ for the probability of working and $\bar{M} = 0.5$ for weekly work hours, implying that the estimated effects remain robust even if post-pandemic violations of parallel trends are up to equal (extensive margin) or 0.5 times (intensive margin) larger than the maximum violation observed in pre-pandemic trends.

Potential mechanisms explaining the impact of COVID-19 on labour outcomes

Next, we investigate potential mechanisms underlying the deterioration of labour market outcomes for individuals

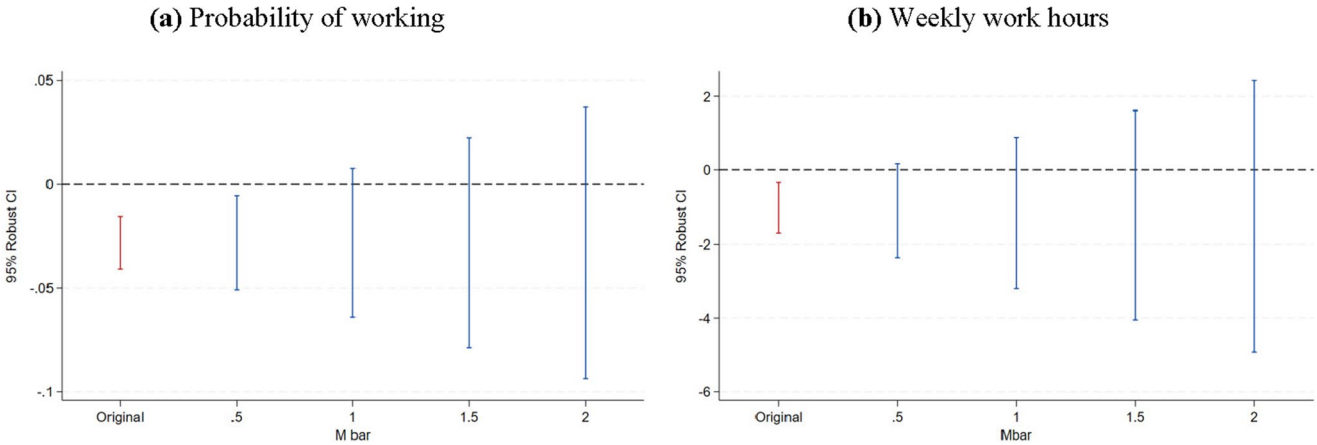

Fig. 8 Sensitivity analysis

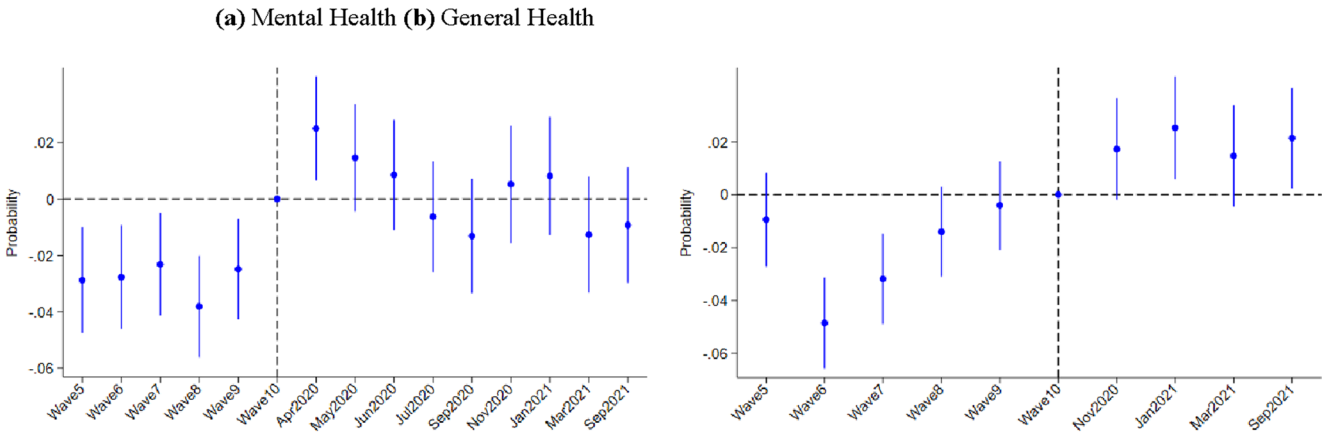

Fig. 9 Mental and general health. *Notes:* Estimated DiD coefficients using the model specified in Eq. 2 with outcome variables (a) the probability of having good mental health and (b) the probability of having good general health

with NCDs following the onset of the COVID-19 pandemic. We focus on several channels: changes in mental and general health, experiencing long COVID, and healthcare resource use (descriptive statistics for these variables are provided in Table A5). Changes in mental and general health are analyzed using the same DiD model specified in Eq. 2. Mental health is measured using the GHQ caseness scale, a widely used indicator of minor psychiatric disorders in the general population [51], with a threshold of 2 to classify poor mental health [52]. General health is classified based on responses to the self-assessed general health question, with a dummy variable equal to 1 if an individual reported "excellent" or "very good" health. While the GHQ variable is available in all COVID-19 waves, general health data are only available from November 2020 onwards, limiting our analysis for this variable to a subset of waves.

Figure 9 shows the estimated impact of COVID-19 on the probability of good mental and general health among individuals with NCDs, with full regression results in Table A6. In the DiD framework, a negative and significant coefficient would indicate that the pandemic worsened health outcomes for NCD individuals relative to non-NCD individuals. As shown in Graph (a), at the the start of the pandemic, the coefficient for mental health is positive, suggesting that NCD individuals initially had a higher probability of good mental health than non-NCD individuals. Over time, this probability declined, and by July–September 2020, after the first UK lockdown, NCD individuals had a lower—but not statistically significant—probability of good mental health relative to non-NCD individuals. A similar pattern is observed for general health, where NCD individuals report a slightly higher probability of good health compared to those without NCDs.

Table 3 Impact of COVID-19 on mental health, general health and healthcare service use of people with NCDS

	Mental health	General health	GP visit (at least 1 visit)	GP visit (more than 3 visits)	Hospital visit (at least 1 visit)
ATT	0.0136*	0.0481***	0.0169**	−0.0779***	−0.0462***
	(0.0074)	(0.0072)	(0.0080)	(0.0077)	(0.0087)

Each estimated coefficient corresponds to separate DID regression; Having good mental health, having good general health, visiting GP at least once a year, visiting GO more than 3 times a year and visiting hospital at least once a year. The mental health variable is generated based on the GHQ caseness scale was used for mental health variable, and the threshold 2 is used to classify poor mental health. General health is based on the response to the self-assessed general health questions, and it is equal to 1 if an individual reported excellent or very good health

Next, we use information from wave 13, treating it as the post-pandemic period,[7] and compare it with pre-COVID waves (waves 5–10) in terms of health status and healthcare use among individuals with NCDs and non-NCDs. The same DiD model as in Eq. 1 is applied. Table 3 presents the estimated DiD coefficients, with full results provided in Table A7. The coefficients for both mental health and general health are positive, suggesting that individuals with NCDs experienced a significant relative improvement in these outcomes compared to those without NCDs, despite having considerably worse baseline health in both domains.

We examined whether healthcare use differed between individuals with and without NCDs before and after the pandemic, focusing on General Practitioner (GP) and hospital visits. As shown in Table 3, the probability of having at

[7] Wave 13 is considered post-pandemic because waves 11 and 12 overlap with the main stages of the pandemic and COVID-19 surveys.

least one GP visit was approximately 2% points higher for individuals with NCDs than for those without NCDs in the post-COVID period relative to the pre-COVID period. In contrast, the likelihood of having more than three GP visits (7 pp) and hospital visits (4 pp) was lower for individuals with NCDs compared to those without NCDs in the post-COVID period relative to the pre-COVID era.

We checked whether the prevalence of long COVID differs between individuals with and without NCDs. Data were available from the last four COVID-19 surveys, spanning November 2020 to September 2021. Respondents were asked whether they had recovered from COVID-19 (if infected) and returned to their previous level of health. Among individuals with NCDs, 10% reported not having returned to their prior health, compared to only 6% of individuals without NCDs. This difference is statistically significant ($chi^2 = 48.36$), indicating that individuals with NCDs were more likely to experience long COVID than those without NCDs.

Discussion and conclusion

This study examined the impact of the COVID-19 pandemic on the labour market outcomes of individuals with NCDs using data from the Understanding Society COVID-19 study in the UK. The survey provides detailed longitudinal data covering nearly two years, capturing the full course of the pandemic. To isolate the effects attributable to the pandemic, we linked these data with the main Understanding Society surveys and employed a Difference-in-Differences (DiD) approach. We further conducted sub-sample analyses to explore heterogeneous effects and validated the robustness of our findings through sensitivity checks.

Our findings indicate that the COVID-19 pandemic had a substantial negative impact on the employment prospects of individuals with NCDs, with effects varying across different stages of the pandemic. In the early phase, the pandemic's impact was relatively modest and affected all individuals regardless of health status. However, as the pandemic progressed, the adverse effects on employment for individuals with NCDs intensified, resulting in a partial withdrawal from the labour market. This negative impact persisted until January 2021, coinciding with the peak of the second wave and the emergence of the Beta variant. By March 2021, the effects on employment had eased slightly, likely reflecting the confidence boost from the vaccine rollout. Nonetheless, the significant decline in employment probability observed by September 2021 highlights ongoing vulnerabilities. In addition, our study found that COVID-19 adversely affected the number of hours worked by individuals with NCDs throughout the pandemic, with work-hour reductions closely mirroring the severity of the pandemic over time.

We also found that the negative impact on employment probabilities was more pronounced among younger individuals compared to older ones, likely reflecting the greater employment stability typically enjoyed by older workers. However, the second wave of the COVID-19 pandemic affected both age groups severely. In terms of work hours, the pandemic caused a larger reduction for younger individuals than for older ones. This pattern aligns with broader trends in the UK labour market, where low unemployment rates during this period were accompanied by rising economic inactivity due to sickness rather than increased employment (ONS, 2020).

The adverse impact of COVID-19 on the work capacity of individuals with NCDs is likely linked to the heightened health risks they faced during the pandemic. We observed that individuals with higher-risk health conditions experienced more pronounced reductions in work hours and employment, particularly in the early stages of the pandemic. NCD individuals were recognized as a high-risk group for severe infection and higher mortality, prompting them to adopt stricter isolation measures [8–10, 53]. These findings are consistent with [54], who show that people with pulmonary disorders were more likely to experience declines in employment probability and work hours, as well as a higher likelihood of being furloughed. Moreover, the intensity of non-pharmaceutical interventions, such as lockdowns, further constrained employment opportunities and work hours, disproportionately affecting those in vulnerable health categories [55].

Our sub-sample analysis of key workers provided additional insights. Although key workers were required to continue working even during the peak of the pandemic, those with NCDs worked fewer hours than their healthy counterparts at the onset of the crisis. However, the reduction in work hours for key workers with NCDs gradually recovered over time, in contrast to the sustained decline in work hours observed among NCD individuals in non-key worker sectors. Despite this recovery, work hours for individuals with NCDs did not return to pre-pandemic levels in either sector by the end of the pandemic.

We also examined potential causal factors contributing to the reduction of employment and work hours among individuals with NCDs during the pandemic, focusing on mental health, general health, healthcare service use, and the impact of long COVID. Our findings did not show a significant negative impact of COVID-19 on the mental health of individuals with NCDs. Additionally, their general health appeared to improve relatively post-pandemic, given their lower baseline health compared to individuals without NCDs. Existing literature highlights the broader adverse effects of the pandemic on mental health across the general population [24, 56–61]. Therefore, it is possible that, in relative terms, individuals with NCDs may have experienced

a slight improvement in health during the pandemic compared to their pre-pandemic baseline.

We found that healthcare service use was slightly lower among individuals with NCDs, which could have impacted their health and, in turn, their labour market outcomes. However, these results should be interpreted with caution. They may be influenced by supply factors, such as relatively stricter access restrictions to healthcare services for those with NCDs, rather than demand factors, such as individuals with NCDs not requiring or choosing not to visit healthcare providers.

Our findings indicate that the prevalence of long COVID is higher among individuals with NCDs compared to those without, which may contribute to their lower labour market outcomes. Long COVID had a significant impact on employment, with individuals experiencing prolonged symptoms facing a higher risk of leaving the workforce. The absence of workplace accommodations for long COVID also played a role in reducing work hours, as many individuals were on sick leave rather than working fewer hours [62].

Based on our findings, we hypothesize that while the pandemic did not worsen the mental or general health of individuals with NCDs, their pre-existing lower health levels may have made them more risk-averse, leading to reduced engagement in the labour market as a means of minimizing health risks. As a result, the decline in work hours and labour market participation among indi-viduals with NCDs during the COVID-19 pandemic in England can largely be attributed to their heightened vulnerability to the virus, the impact of long COVID, and the effects of public health interventions. These factors prompted the adoption of protective measures, such as furloughs and remote work, to safeguard their health.

Our study has several limitations. First, health status was self-reported, which could lead to biases, as individuals may overestimate or underestimate their health conditions, particularly in the context of subjective measures like mental health. This could lead to inaccurate reporting of ill health or failure to report mild conditions. Additionally, prioritizing COVID-19 vaccination for individuals with long-term health conditions may have contributed to overreporting of ill health in this group, as those with more severe health conditions were more likely to be vaccinated early in the pandemic. Secondly, attrition in longitudinal surveys, particularly during a major crisis like the pandemic, may introduce bias if individuals with NCDs are more likely to drop out of the study due to worsening health or other pandemic-related factors. This non-random attrition could affect the representativeness of the sample, potentially underestimating or overestimating the pandemic's impact on labour market outcomes for individuals with NCDs. Thirdly, the variable for employment category was not coded consistently pre- and post-pandemic. In the COVID-19 study data, there was a category for 'both employed and self-employed,' which was not available in pre-pandemic surveys. As a result, we were unable to estimate the pandemic's impact on this specific category separately and therefore combined employed, self-employed, and both groups into a single category when analyzing the working population.

Despite these limitations, this study highlights the disproportionate impact of the COVID-19 pandemic on individuals with NCDs, who faced significant declines in labour outcomes due to heightened health risks, long COVID, and public health interventions. To address these challenges, policymakers should focus on several key areas. First, implementing workplace accommodations, such as flexible work arrangements and remote work, for individuals with long COVID to prevent employment drop-outs and support ongoing employment. Additionally, employers could offer targeted employment support for younger individuals with NCDs, such as training programs and mental health support to offset the disproportionate impact the pandemic had on this group. Attention should also be given to individuals who have exited the labour market due to the combined effects of NCDs and COVID-19. Policymakers need to assess the welfare of these individuals to ensure they are not pushed to financial hardship or left vulnerable.

While this study provides valuable insights into the labour market outcomes of individuals with NCDs during the COVID-19 pandemic in the UK, its findings may also have relevance for other countries, though with important contextual considerations. Public health interventions, such as strict lockdowns, widespread vaccination campaigns, and government-supported furlough schemes, played a significant role in shaping the labour market impacts of the pandemic in the UK and elsewhere. However, the strength and nature of these interventions varied widely across countries, which could potentially influence the extent to which individuals with NCDs were affected. In contexts where public health responses were less stringent or where social safety nets were weaker, the adverse effects on labour outcomes for individuals with NCDs might have been more pronounced. Therefore, while the general trends observed in the UK may hold in other contexts, the specific policy responses in each country will significantly shape the extent of these effects.

In light of our findings, further research is needed to explore additional mechanisms driving the reduction in employment and work hours among individuals with NCDs during the pandemic. Future studies should also examine cross-country variations to better understand how differing public health interventions impact labour market outcomes for vulnerable populations. A deeper understanding of these dynamics will be essential for developing targeted policies that can mitigate the adverse labour market effects faced by this group and support their ongoing participation in the workforce.

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Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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