Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Short communication

Excess mortality during the Covid-19 pandemic: Early evidence from England and Wales

Sotiris Vandoros[a,b]

[a] King's College London, Bush House, 30 Aldwych, WC2B 4BG, London, United Kingdom
[b] Harvard T.H. Chan School of Public Health, Boston, MA, USA

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ABSTRACT

The Covid-19 pandemic has claimed many lives in the UK and globally. The objective of this paper is to study whether the number of deaths not registered as Covid-19-related has increased compared to what would have been expected in the absence of the pandemic. Reasons behind this might include Covid-19 underreporting, avoiding visits to hospitals or GPs, and the effects of the lockdown. I used weekly ONS data on the number of deaths in England and Wales that did not officially involve Covid-19 over the period 2015–2020. Simply observing trends is not sufficient as spikes in deaths may occasionally occur. I thus followed a difference-in-differences econometric approach to study whether there was a relative increase in deaths not registered as Covid-19-related during the pandemic, compared to a control. Results suggest that there were an additional 968 weekly deaths that officially did not involve Covid-19, compared to what would have otherwise been expected. It is possible that some people are dying from Covid-19 without being diagnosed, and/or that there are excess deaths due to other causes as a result of the pandemic. Analysing the cause of death for any excess non-covid-19 deaths will shed light upon the reasons for the increase in such deaths and will help design appropriate policy responses to save lives.

1. Background

Over 5.5 million Covid-19 cases have been reported globally, leading to 350,000 deaths as of 27 May 2020. In the United Kingdom, the death toll has reached 37,000, while over 265,000 people have been diagnosed with the virus as of the same date (Johns Hopkins University, 2020). The novel coronavirus is directly claiming lives, and it is also possible that some Covid-19 patients may have died without being diagnosed. However, this unprecedented situation and the lockdown might also be triggering additional health problems. People with other, unrelated health conditions may be reluctant to visit their GP or a hospital in order to avoid the risk of contracting the virus (New York Times, 2020a), thus remaining undiagnosed or not receiving the medical treatment they might need. The UK government has therefore urged the public to seek medical attention when needed (BBC, 2020a). Nevertheless, to increase capacity for the overstretched NHS, routine operations have been postponed (The Guardian, 2020a).

The lockdown may also have unintended health effects. Lack of social contact can affect mental health (Kawachi and Berkman, 2001), and big events or disasters at the national level can have a similar impact (Metcalfe et al., 2011). Staying at home can limit physical activity, which has been associated with obesity (Lahti-Koski et al., 2002) and mental health (Saxena et al., 2005). There are also reports of a rise in domestic abuse (New York Times, 2020b), while the current financial and public health situation may also cause additional uncertainty and stress, which have negative health consequences (Vandoros et al., 2019; Noelke and Avendano, 2015). Apart from the negative effects, there may also be some improvement in certain areas. The lockdown has reduced traffic volume and may thus lead to a decrease in motor vehicle collisions – although empty roads provide an opportunity to speed (The Guardian, 2020b). Reduced traffic has also led to lower levels of air pollution, which is associated with mortality (Di et al., 2017). The lockdown may have also helped reduce crime rates.

There are reports of excess mortality in some countries during the Covid-19 pandemic. Rivera et al. (2020) found that Covid-19 mortality figures in the US underestimate the actual death toll, and that Covid-19 mortality is likely to be twice as high as reported. The authors suggest that there may also be indirect fatalities, including patients not seeking care or being turned away from emergency departments. Evidence from Portugal suggests that excess mortality was 3–5 times higher than what could be explained by Covid-19 deaths (Nogueira et al., 2020). Similar evidence has been reported in Italy (Modi et al., 2020; Gibertoni et al., 2020). In Scotland, recent empirical evidence suggests the presence of excess deaths due to cancer, dementia, circulatory and respiratory

E-mail address: vandoros@hsph.harvard.edu.

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diseases and other causes in the early stages of the Covid-19 outbreak (Oke and Heneghan, 2020). This follows warnings about delays in diagnosis and treatment in cancer due to the pandemic (ITV, 2020).

The objective of this paper is to study whether and to what extent the number of deaths not registered as Covid-19-related have increased in England and Wales compared to what would have been expected in the absence of the virus. This may be a result of some Covid-19 deaths being unreported and/or spillover effects on other causes of death.

2. Data and methods

This study used weekly (provisional) mortality data from England and Wales for years 2015-2020, obtained from the Office for National Statistics (ONS, 2020). Data were extracted on 7 April 2020 and updated on 14, 21, 28 April and on 5 and 12 May 2020. Data used in this study are based on the release on 12 May 2020, and values included in this dataset may be changed in later releases, as is sometimes the case. Data were reported by gender, age group and Region. I used the total number of deaths (regardless of cause) as well as the number of deaths where Covid-19 was mentioned on the death certificate, in order to calculate the number of deaths that were not officially related to Covid-19. Information on Covid-19 deaths is also available by the Department of Health and Social Care (2020) but the latter exclude those deaths that occurred outside hospital, which is why I preferred the ONS dataset. According to the ONS, data by gender or age group may be incomplete, so they might not necessarily sum to the total number of deaths. Although information on the cause of death would be very useful in this analysis, such detail is not yet available for the study period. Summary statistics are presented in Table 1.

Studying trends in a variable alone before and after a "treatment" can be misleading as there may be other factors driving any change. For that purpose, a control group can help filter out any other effects. Such a control group will have to remain unaffected by the treatment. The Covid-19 pandemic is a major global crisis, and has caused a lockdown throughout the UK, so identifying a control population for the same period seems impossible as it would be highly likely to be contaminated. Instead, I follow an approach similar to that by Metcalfe et al. (2011) and Powdthavwee et al. (2019) who used trends in the same variable, in earlier years, as a control group. Likewise, I used deaths in the first 18 weeks in previous years as a control group for non-covid-19 deaths in the 18 first weeks in 2020. The "treatment" period starts in week 10 of the year, when the first covid-19 death occurred in England and Wales (BBC, 2020b). The lockdown in the United Kingdom started on 23 March, i.e. in the 13th week of the calendar year (BBC, 2020c).

In order to compare trends in deaths *excluding covid-19 deaths* to the control group, I used a difference-in-differences (D-I-D) econometric approach. I used the average number of deaths in the five previous years as a control group, which also helps smooth out any short-term spikes (possibly due to a bad flu season (National Flu Reports, 2020)). The common trend assumption, which is a requirement in a difference-in-differences approach, is met (results reported in Section 3).

The dependent variable is the number of deaths in each of the 18 first weeks of the calendar years, excluding any deaths that mentioned Covid-19 in the death certificate. The difference-in-differences model includes a "treatment group" dummy variable, which takes the value of 1 for the group that is affected by the intervention, and zero otherwise. In this case, observations in 2020 take the value of 1, and observations in previous years take the value of zero. Another dummy that is included is an "after" variable, which takes the value of 1 in the period after an intervention (i.e. from week 10 each year, for both groups, 2020 and other years), and zero otherwise. The interaction of these two dummy variables (treatment*after) is the main variable of interest. I also used dummy variables for gender and week dummies, to address seasonality. Robust standard errors were used in all regressions.

Could any relative increase in deaths be random? To answer this, I performed a placebo test, restricting the sample to the pre-treatment period (up to week 9, i.e. before the first Covid-19 death), using an earlier random treatment period starting in week 7. Finding no effect in this case would lend additional support that the findings of the baseline model are not random.

Finally, for completeness, I also employed an interrupted time series model, using *all* weekly observations (not the average) from the first week of 2015 until the 18th week of 2020 (279 observations in total). Again, the treatment period starts in the tenth week of 2020, which does indeed leave a very short post-treatment period (9 weeks) compared to the pre-treatment period (270 weeks). However, this approach is used as an additional check rather than as the main analysis.

Table 1
Summary Statistics, number of weekly deaths not registered as Covid-19-related.

	Weeks 1–9		Weeks 10–18	
	Average 2015-19	2020	Average 2015-19	2020
Females	6370.44	5969.44	5379	5934.11
	(491.14)	(632.58)	(276.56)	(1049.86)
Males	7198.33	5847.44	6199.78	5827.78
	(459.99)	(496.09)	(284.58)	(958.66)

Standard errors in brackets.

3. Results

There are 3268 additional deaths that did not officially involve Covid-19 in week 18 of 2020, compared to the same week in years 2015–2019 on average. Fig. 1 shows the weekly number of deaths by gender in England and Wales (excluding any covid-19 deaths) in the first 18 weeks of 2020 and the average weekly deaths for the period 2015–2019. On week 14, 2020, onwards, there is a jump in non-covid-19 deaths, compared to the trend in previous years. This increase only started in week 14, i.e. in the fifth week of reported covid-19 fatalities. In week 13 2020 (which was the fourth week of covid-19 fatalities), the number of non-covid-19 deaths demonstrated a relative decrease. Figure A1 in the Appendix provides trends in non-covid-19 deaths by age group and gender, for age groups 65–74; 75–84; and 85 or over, which account for over 85% of all deaths.

A difference-in-differences approach requires that the trends (rather than absolute values) in treatment and control groups are parallel prior to the intervention. To test whether this common trend assumption is met, I followed the approach by Autor (2003), who used a model with interactions including lags and leads (prior to and after the treatment). Results of the common trend test are presented in Table A1 in the Appendix. All interaction *lags* are insignificant, suggesting that there is indeed a common trend in the two groups prior to the intervention. Trends can also be observed graphically (Fig. 1).

Results of the baseline difference-in-differences econometric analysis are presented in Table 2, where weekly deaths enter the model by gender. There is an increase in deaths not reported as Covid-19-related in the post-treatment period compared to the control group [D-I-D coeff: 967.50; 95%CI: 470.55 to 1464.45].

Results of the placebo test (restricting the sample to the pre-treatment period, up to week 9, i.e. before the first covid-19 death) are provided in Table 3. Indeed, there is no effect in this placebo regression [D-I-D coeff: -23.08; 95%CI: -463.44 to 417.27].

I also performed the analysis at the Region level (Wales and nine regions in England). Results are reported in Table A2 in the Appendix, and confirm the findings of the baseline model [D-I-D coeff: 166.90; 95%CI: 122.06 to 211.74].

Results of the interrupted time series analysis are reported in Table A3 in the Appendix and suggest a similar effect, indicating an increase in the weekly deaths trend compared to the pre-treatment period [coef:

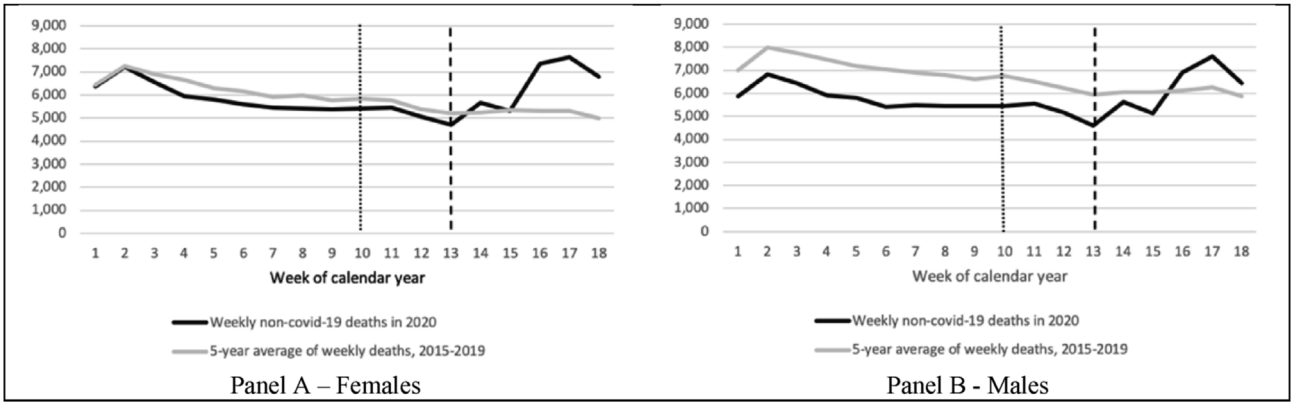

Fig. 1. Weekly deaths in England and Wales not registered as covid-19-related, first 18 weeks, year 2020 and average of years 2015–2019. First covid-19 death in week 10 (dotted vertical line). Lockdown introduced in week 13 (dashed vertical line). Based on ONS data published on 12 May 2020.

Table 2
D-i-D regression results.

Dependent variable: Weekly number of non-covid-19 deaths by gender	
DID coefficient	967.50***
	[470.55 to 1464.45]
treatment group	−875.94***
	[-1087.45 to −664.44]
treatment period (week 10 onwards)	−899.75**
	[-1764.73 to −34.77]
female	−355.08***
	[-603.56 to −106.61]
week dummies	yes
Constant	7043.764***
	[6660.41 to 7427.12]
Observations	72
R-squared	0.68
F-statistic	17.13

Robust ci in brackets. Dependent variable: Number of weekly deaths officially *not* reported as covid19-related deaths in first 18 weeks of calendar year. Years: 2020 and average of 2015–2019. Based on ONS data published on 12 May 2020. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 3
Placebo test.

Dependent variable: Weekly number of non-covid-19 deaths by gender	
Placebo DID coefficient	−23.08
	[-463.44 to 417.27]
treatment group	−868.25***
	[-1161.50 to -575.00]
placebo treatment period	−625.21**
	[-1144.79 to −105.63]
female	−352.94***
	[-577.03 to −128.86]
week dummies	yes
Constant	7038.85***
	[6659.23 to 7418.46]
Observations	36
R-squared	0.87
F-statistic	24.08

Robust CI in brackets. Dependent variable: Weekly number deaths not registered as covid-19-related by gender in first 9 weeks of calendar year. Years: 2020 and average of 2015–2019. Placebo treatment: Week 7 onwards. Based on ONS data published on 12 May 2020. ***p < 0.01, **p < 0.05, *p < 0.1.

656.78; 95% CI: 410.63 to 902.94].

4. Discussion

This paper studied whether, during the Covid-19 pandemic, there was an increase in deaths that have not been officially reported as linked to the virus. Using a differences-in-differences econometric approach by comparing trends in 2020 to the average trends in the previous five years, I find that there are an additional 968 weekly deaths not officially registered as Covid-19 compared to what would have been expected in the absence of the pandemic. Therefore, apart from the official Covid-19 death toll, there are additional deaths that might be linked, either directly or indirectly, to Covid-19. Such evidence is in line with excess mortality reported in other countries (Modi et al., 2020; Oke and Heneghan, 2020; Gibertoni et al., 2020; Rivera et al., 2020; Nogueira et al., 2020).

There are two possible reasons for this excess mortality. First, some people might have died from Covid-19 without being diagnosed (Rivera et al., 2020; Modi et al., 2020). Second, there may be spillover effects on other causes, such as patients postponing treatment for unrelated health conditions in order to avoid contracting the virus in hospitals or GP clinics; prioritisation of covid-19 patients by health services; stress and anxiety related to the current financial and public health environment; domestic violence; and lack of activity or other effects due to the lockdown (Kawachi and Berkman, 2001; Metcalfe et al., 2011; Lahti-Koski et al., 2002; Saxena et al., 2005; Vandoros et al., 2019; Noelke and Avendano, 2015; New York Times 2020a, 2020b; The Guardian, 2020a). Such excess mortality due to other reasons has been reported in Scotland, where information on the cause of death is available (Oke and Heneghan, 2020), and echoes concerns about diagnosis and treatment of cancer patients (ITV, 2020). This relative increase in deaths occurs despite reasonably expecting a reduction in some types of mortality, such as those associated with crime, pollution or smoking.

The way deaths are reported or registered is central to this research question. In the ONS data, coronavirus deaths are those that mention covid-19 on the death certificate, meaning that one may have died due to other causes, after having tested positive for Covid-19. In any case, reporting deaths is challenging, and misclassification can often play a role in empirical results (Vandoros, 2020; Flegal et al., 2018; Kapusta et al., 2011). Furthermore, weekly data updates often include revisions on provisional figures from previous weeks.

It is worth noting that the increase in deaths seems to only occur from week 14 onwards, i.e. in the fifth week since the first covid-19 death in the country - when there were already over 2000 covid-19 deaths in England and Wales. For any excess deaths that might have been a result of not visiting a hospital or GP clinic due to fear of contracting a disease, it may be that either people changed their behaviour only when Covid-19 deaths started rising steeply, or that any untreated health issues led to death with a time lag. Using a treatment period in the empirical model that would start later into the pandemic would show an even larger magnitude of non-covid-19 deaths.

This study is subject to limitations. We are not able to see to what extent excess deaths are underreported Covid-19 deaths or due to other reasons. Information on the causes of death would help disentangle the two, but data on the cause of death for this period are not yet available by the ONS. Furthermore, this study reflects the situation in the early stages of the Covid-19 pandemic, and thus reports the situation in the short term. Results are also specific to England and Wales and are not generalisable to other countries.

With regards to the methodological approach, I considered the treatment period to start in week 10, as that is the week when the first covid-19 death was reported, thus indicating an escalating situation and capturing any spillover effects of the virus. One might argue that the treatment period should start later, when the number of deaths started increasing steeply, but a question that remains is where we should draw the line, and this would possibly relate with the cause of excess deaths, which is currently unknown – so identifying where the treatment period should start becomes particularly challenging. To be on the safe side, I followed the most conservative approach, i.e. a treatment period that starts with the first death, rather than when the number of deaths demonstrate large increases. This might underestimate the magnitude of any effect on non-covid-19 deaths, but is unlikely to exaggerate the findings.

If people are dying of Covid-19 without being diagnosed, mortality may actually be higher than what we currently think. If people without Covid-19 are also dying as a result of the virus, we to need act urgently, to minimise these tragic spillover effects. Data access on the causes of non-covid-19 deaths would allow us to understand the mechanism behind this phenomenon and would help design appropriate targeted responses to save lives.

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Ethics approval

The data used were aggregate anonymous data from a public source so ethics approval was not required.

Data availability

The data used in this study are freely available online from the Office for National Statistics.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2020.113101.

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