


Excess mortality caused by the COVID-19 pandemic negatively impacts birth numbers in European countries

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Submitted on July 18, 2021; resubmitted on January 14, 2022; editorial decision on February 1, 2022

STUDY QUESTION: How did the coronavirus disease 2019 (COVID-19) pandemic affect live birth numbers in Europe?

SUMMARY ANSWER: In 14 European countries with validated datasets on live birth numbers during the ongoing COVID-19 pandemic, excess mortality was inversely correlated with live birth numbers.

WHAT IS KNOWN ALREADY: Since March 2020, in order to minimize spread of severe acute respiratory syndrome coronavirus 2 and reducing strain on the health care systems, many national authorities have imposed containments and restricted both indoor and outdoor recreational activities. Historical events, such as electricity blackouts, have repeatedly been shown to exert incremental effects on birth numbers.

STUDY DESIGN, SIZE, DURATION: We evaluated the effect of the COVID-19 pandemic and the containments on reproduction and birth numbers in 14 European countries with complete and validated datasets, until March 2021.

PARTICIPANTS/MATERIALS, SETTING, METHODS: The national demographic offices of 20 European countries were requested to provide the monthly birth numbers from 2015 to March 2021. Among them, 14 countries provided those data. Taking into account seasonal variations, the live birth numbers were compared with excess mortality at two different time intervals during the pandemic.

MAIN RESULTS AND THE ROLE OF CHANCE: At 9 months after the initiation of containments in many European countries, 11 of 14 European countries (78.5%) experienced a decline in live birth numbers, ranging between -0.5% and -11.4% . The decline in live birth numbers was most pronounced in eight European countries with the highest degree of excess mortality. From January to March 2021, live birth numbers continued to decline in 5 of 8 European countries with high excess mortality, whereas live births started to recover in 8 of 14 countries (57.1%).

LIMITATIONS, REASONS FOR CAUTION: The live birth numbers of some key European countries were not available.

WIDER IMPLICATIONS OF THE FINDINGS: The demographic changes linked to the COVID-19 pandemic may add to the overall socio-economic consequences, most particularly in those countries with pre-existing reduced reproduction rates.

STUDY FUNDING/COMPETING INTEREST(S): This study did not receive specific funding. The authors have no conflicts of interest to declare.

TRIAL REGISTRATION NUMBER: N/A.

Key words: COVID-19 / live birth numbers / mortality / reproduction / pandemic / containment / seasonality / fertility / family planning / contraception

Introduction

The World Health Organization declared coronavirus disease 2019 (COVID-19) a pandemic on 11 March 2020. Confronted with the outbreak of the pandemic, initially in China in late 2019 and in Italy from January 2020 onward, and then rapidly spreading, the authorities of most European countries reacted by imposing travel restrictions, by closing public spaces including schools, and by reducing social contacts through both regional and national lockdowns. The COVID-19 caseload in each European country followed different waves at different time points, as did the degree and duration of containments, which were imposed in most European countries in March 2020. All these measures had a profound global disruptive effect on socio-economic activities, which, together with the costs of increased public expenditure, are likely to have a long-lasting impact on society. In some countries, including England and Wales, the excess mortality owing to the COVID-19 pandemic has been demonstrated to exert a shortening of overall life expectancy (Aburto et al., 2021; Spiers et al., 2021). The effect of the COVID-19 pandemic on live birth numbers has remained unexplored so far. Uncertainty about the economic prospects and concerns about the impact of a COVID-19 infection during pregnancy on the health status of both mother and offspring may have resulted in fewer pregnancies, but containment at home may also have provided the opportunity for more intimacy among couples, resulting in pregnancies. Historical events, such as power outages/electricity blackouts, reducing both indoor and outdoor recreational activities, have repeatedly been shown to exert incremental effects on birth numbers (Udry, 1970; Burlando, 2014). COVID-19 may also directly interfere with male and female fertility (Jing et al., 2020; Wang et al., 2020; Aitken, 2021; Gacci et al., 2021). Here, we quantify the live birth numbers in several European countries before and during the COVID-19 pandemic and correlate these with excess mortality during the pandemic.

Materials and methods

The very different attitudes and management approaches of the authorities during the COVID-19 pandemic in the various European countries, together with distinct incidences of infection and mortality rates, provide an excellent opportunity to evaluate the differential impact of the pandemic on live birth numbers. We therefore surveyed the available datasets from the public health offices of 20 European countries or contacted them by email and retrieved monthly live birth numbers from 2015 to March 2021 in 14 of the 20 contacted countries (Supplementary Table S1 and Figs S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, which include the data of 4 countries with incomplete or not yet validated datasets). No such datasets were made available from Ireland and Greece. No data from January to March 2021 were available from England, Wales and Luxembourg. The live birth numbers from Scotland and Northern Ireland in 2020 and 2021 were labeled as provisional.

Description of P-scores

During the ongoing pandemic, COVID-19 detection methods changed over time and differed among countries. For that reason, comparison between the COVID-19 caseload and birth numbers was not feasible.

Instead, excess mortality is considered the more reliable measure of the impact of the pandemic (Leon et al., 2020; Cerqua et al., 2021; Giattino et al., 2021). Based on this, we compared the monthly birth numbers with the excess mortality in 14 European countries. Weekly mortality numbers from all included countries are available online (www.mortality.org) (Németh et al., 2021). Owing to differences in population sizes, the raw numbers do not allow the comparison of the effects of the pandemic on the demographic events among countries. The *P*-score measures excess mortality as the percentage difference between the observed mortality during the pandemic and that before the pandemic, and is commonly used to compare the impact of the pandemic on excess mortality rates among countries (Giattino et al., 2021). For each of the 14 European countries with complete and validated datasets, we calculated the excess mortality *P*-score using the following formula:

P-score excess mortality (%)

$$= \frac{\left\{ \begin{array}{l} \text{[no. deaths during pandemic / no. weeks]} \\ - \text{[no. deaths before pandemic / no. weeks]} \times 100 \end{array} \right\}}{\text{[no. deaths before pandemic / no. weeks]}}$$

We compared the excess mortality *P*-score 2020 with that of 2015–2019. In analogy, we also calculated differences in the live birth numbers using the *P*-score formula:

P-score live births (%)

$$= \frac{\left\{ \begin{array}{l} \text{[no. live births during pandemic / no. months]} \\ - \text{[no. live births before pandemic / no. months]} \times 100 \end{array} \right\}}{\text{[no. live births before pandemic / no. months]}}$$

Birth numbers were only available per month. As live birth numbers are characterized by seasonal variability, we compared the live birth number *P*-scores during the time interval from October 2020 to December 2020 (9 months after the outbreak of the pandemic in Europe) with the time interval from October 2019 to December 2019 (before the outbreak). We also compared the live birth number *P*-scores from January 2021 to March 2021 (most recent phase of the pandemic with available birth number datasets) with those from January 2020 to March 2020 (early in onset of the pandemic in Europe).

Statistical analysis

We compared the excess mortality *P*-scores 2020 with the live birth *P*-scores of the 14 European countries using both Spearman rank correlation (r_s) and linear regression analysis.

Differences in live birth *P*-scores between the five countries with the highest excess mortality rates (*P*-scores >10%) were compared with those of the nine countries with lesser excess mortality rates (*P*-score <10%). The differences between both groups were analyzed with the Mann–Whitney *U*-test and the results presented by their median values ± interquartile range. Statistical analyses were carried out with IBM SPSS Statistics Workpackage 24 (Chicago, IL, USA).

Results

Live birth *P*-scores were compared with excess mortality *P*-scores during two different time intervals after the onset of the COVID-19

pandemic. The live birth *P*-scores of all 14 European countries from October to December 2020 (Fig. 1A) are presented in columns and compared with the excess mortality *P*-scores during the same time interval. Similarly, the live birth *P*-scores from January to March 2021 are presented in columns and ranked according to excess mortality *P*-scores (Fig. 1B), with the five most affected on the right. The first time interval was chosen to start ~9 months after the initiation of containments in most European countries, and the second approximately after 12 months. In each of the two comparisons, the results of the Spearman rank correlation indicated that there was a significant negative association between the excess mortality *P*-scores and the live birth *P*-scores: $r_s = -0.7418$ in January to March 2021; $r_s = -0.7231$ in October to December 2020 (both $P = 0.005$) (Fig. 2). Among the 14 European countries with complete and validated live birth datasets, only three countries (Iceland, Finland and Germany) reported a positive live birth *P*-score both 9 and 12 months after the start of the pandemic (Fig. 2 and Table I).

At 9 months after the initiation of containments in most European countries, 11 of 14 European countries experienced a

decline in live birth *P*-scores, ranging between -0.5% and -11.4% (Fig. 1A). The decline in live birth *P*-scores was significantly more pronounced in countries with excess mortality *P*-scores $>10\%$ as compared to countries with excess mortality *P*-score $<10\%$ (median -4.5% versus $+0.2\%$, respectively, $P = 0.008$). When comparing the live birth *P*-scores from January to March 2021 (12 months after the onset of the pandemic) (Fig. 1B) with the live birth *P*-scores from October to December (9 months after the onset of the pandemic in Europe) (Fig. 1A), the live birth *P*-scores in five of eight countries with high excess mortality (P -score $>10\%$) continued to decline. The decline in live birth *P*-scores was significantly more pronounced in countries with excess mortality *P*-score $>10\%$ (-6.8% versus $+5.3\%$, respectively, $P = 0.012$). Whereas in October to December 2020, the live birth *P*-scores were positive in 3 of 14 countries (Fig. 1A), in 8 countries the live birth *P*-scores were on the rise during first 3 months of 2021 (Fig. 1B). This discrepant evolution of excess mortality and live birth numbers in different European countries corresponds with the different slopes of the regression lines (Fig. 2), correlating excess mortality *P*-score and live birth *P*-

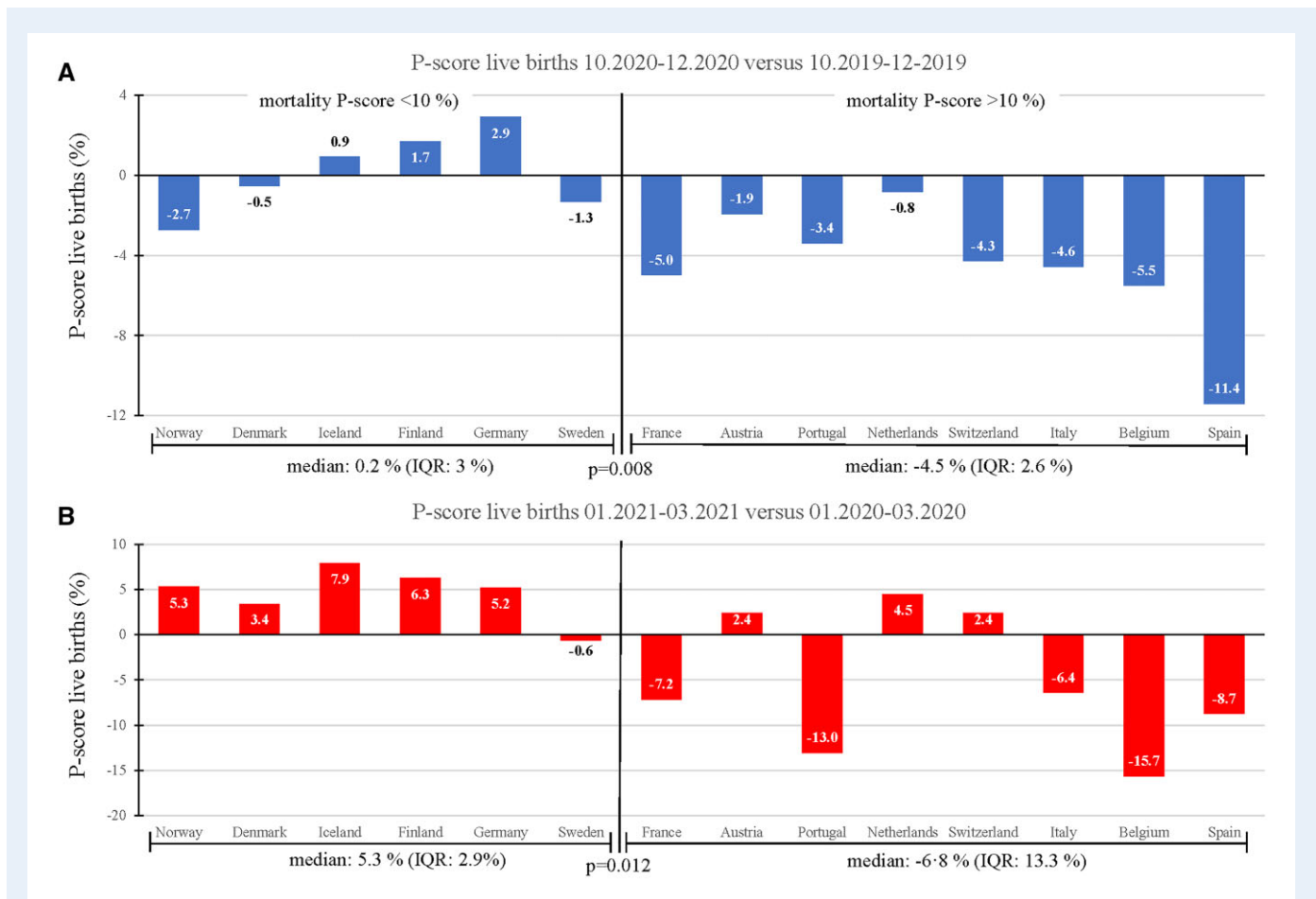


Figure 1. Live birth numbers in Europe during the ongoing coronavirus disease 2019 pandemic. The live birth *P*-scores, as given in percentages and registered in October to December 2020 (A) and in January to March 2021 (B), were ranked according to excess mortality *P*-scores in 14 European countries. The mean live birth *P*-scores (with standard deviation) of the eight most affected countries with excess mortality *P*-scores $>10\%$ were compared with those of the six less affected countries with excess mortality *P*-scores $<10\%$ at two different time intervals during the pandemic. IQR, interquartile range.

score, which were observed during the two different phases of the ongoing pandemic ($\beta = -0.458$ in October to December 2020 to $\beta = -0.949$ in January to March 2021), despite a similar monotonic

relation (from $r_s = -0.7231$ in October to December 2020 to $r_s = -0.7418$ in January to March 2021).

Discussion

We aimed to quantify the impact of the pandemic and of the containments on the birth numbers in European countries 9 months after onset of the COVID-19 pandemic in Europe. The often repeated and long-lasting containments imposed by the authorities of most European countries on their citizens and inhabitants during the COVID-19 pandemic have restricted travel and both indoor and outdoor recreational activities. Similar historical containments caused by power outages and electricity blackouts in the past have resulted in higher live birth numbers (Udry, 1970; Burlando, 2014). However, the current survey demonstrates an opposite effect: in 11 of 14 European countries with validated and complete datasets, a drop in the monthly birth numbers was observed ~ 9 months after the early phase of the pandemic (Figs 1 and 2). The drop in live birth numbers, as given by live birth P -scores, was most pronounced in those countries with the highest excess mortality P -score (Fig. 2).

Socio-economic considerations may have motivated affected populations to refrain from pregnancy (Aassve et al., 2020; Kahn et al., 2021), as has been observed in the USA (Chandra et al., 2018) and among the Maori population of New Zealand (Wilson et al., 2019) 9 months after the first excess death peak during the Spanish influenza pandemic of 1918–1920. Concerns about the higher incidence of complications caused by COVID-19 during pregnancy may have played a minor role (Favre et al., 2020; Rasmussen et al., 2020; Sentilhes et al., 2020). Although COVID-19 may also interfere directly with fertility,

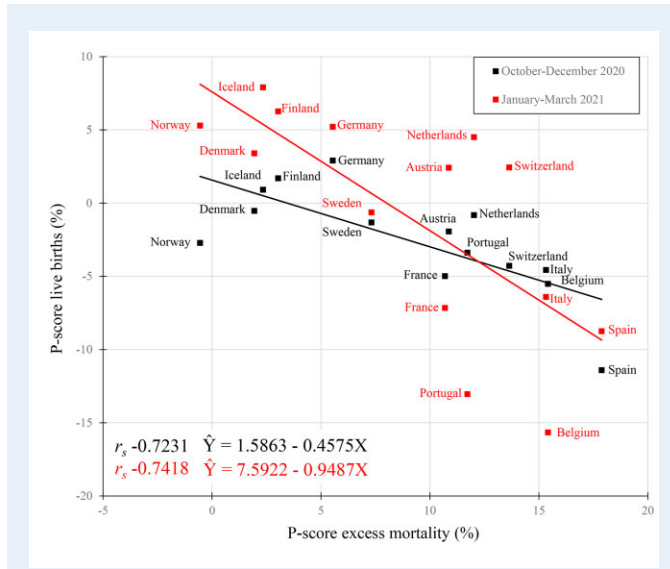


Figure 2. Live birth numbers versus excess mortality in Europe during the coronavirus disease 2019 pandemic. Using Spearman rank analysis (r_s), we correlated excess mortality P -scores (2020) with the live birth P -scores from October to December 2020 (black squares and line) and from January to March 2021 (red squares and line) in 14 European countries with complete and validated datasets. For visualization purposes, we added linear regression lines together with the corresponding equations.

Table 1 Excess mortality P -scores and live birth P -scores for 14 European countries at different time points in the coronavirus disease 2019 pandemic.

Countries	Excess mortality, 2020–March 2021 (P -score, in %)	Live births, October to December 2020 (P -scores, in %) ¹	Live births, January to March 2021 (P -score, in %) ²
Norway	−0.5	−2.7	+5.3
Denmark	1.9	−0.5	+3.4
Iceland	2.3	+0.9	+7.9
Finland	3.0	+1.7	+6.3
Germany	5.5	+2.9	+5.2
Sweden	7.3	−1.3	−0.6
France	10.7	−5.0	−7.2
Austria	10.9	−1.9	+2.4
Portugal	11.7	−3.4	−13.0
The Netherlands	12.0	−0.8	+4.5
Switzerland	13.6	−4.3	+2.4
Italy	15.3	−4.6	−6.4
Belgium	15.4	−5.5	−15.7
Spain	17.9	−11.4	−8.7

¹Nine to 11 months after the onset of the pandemic.

²Twelve to 15 months after the onset of the pandemic. For excess mortality, all months in 2020 were used.

particularly the male partner (Aitken, 2021; Gacci *et al.*, 2021), this effect can only be marginal.

The economic and financial consequences of excess mortality as caused by COVID-19 have been discussed intensively (Lui *et al.*, 2021). The effect of fewer children born during the pandemic has not yet become part of the debate. In several European countries, an up to 13% decline in live birth numbers was observed in 2020 and 2021. This decline is most pronounced in those countries with already low pre-pandemic reproduction rates (Supplementary Data) and became more accentuated during the first 3 months of 2021 in countries that experienced the highest excess mortality (Fig. 1B).

In contrast to historical events, such as power outages and electricity blackouts, which often resulted in an intermediate rise in birth numbers, the COVID-19 pandemic significantly reduced the birth numbers in most European countries, most particularly in those with the highest excess mortality rates. The demographic consequences of this decline in birth numbers in European countries must be acknowledged in the current debate on the long-term economic consequences of the COVID-19 pandemic.

Supplementary data

Supplementary data are available at *Human Reproduction* online.

Data availability

The data underlying this article are available in the article and in its online supplementary material.

Acknowledgements

We are grateful for the sharing of data from the following national statistics offices: Bundesamt für Statistik (BfS), Switzerland; Institut national de la statistique et des études économiques (insee), France; Statistisches Bundesamt, Deutschland; La Belgique en Chiffres, Belgium; Instituto Nacional de Estadística, Spain; statec-gouvernement, Luxembourg; Office for National Statistics, England and Wales; National Records of Scotland, Scotland; Northern Ireland Statistics and Research Agency, Northern Ireland; CBS, the Netherlands; Bundesanstalt Statistik Österreich, Austria; Population and Education, Social Statistics; INE-Instituto Nacional de Estatística, Portugal; Statistics Sweden, Population and Economic Welfare statistics unit, Sweden; Statistics Norway, Norway; Official statistics of Finland, Finland; Statistics Iceland, Iceland; and Istituto nazionale di statistica (ISTAT), Italy.

Authors' roles

C.D.G.—conception of the design, data acquisition and analysis, interpretation and writing.

M.M.—data acquisition and analysis, interpretation of the results and final approval.

U.G.-K.—data analysis, interpretation of the results and writing.

Funding

This survey did not receive specific funding.

Conflict of interest

All authors declare no competing interests.

References

- Aassve A, Cavalli N, Mencarini L, Plach S, Livi Bacci M. The COVID-19 pandemic and human fertility. *Science* 2020;**369**: 370–371.
- Aburto JM, Kashyap R, Schöley J, Angus C, Ermisch J, Mills MC, Dowd JB. Estimating the burden of the COVID-19 pandemic on mortality, life expectancy and lifespan inequality in England and Wales: a population-level analysis. *J Epidemiol Community Health* 2021;**75**:735–740.
- Aitken RJ. COVID-19 and human spermatozoa—potential risks for infertility and sexual transmission? *Andrology* 2021;**9**:48–52.
- Burlando A. Power outages, power externalities, and baby booms. *Demography* 2014;**51**:1477–1500.
- Cerqua A, Di Stefano R, Letta M, Miccoli S. Local mortality estimates during the COVID-19 pandemic in Italy. *J Popul Econ* 2021;**34**: 1189–1217.
- Chandra S, Christensen J, Mamelund SE, Paneth N. Short-term birth sequelae of the 1918–1920 influenza pandemic in the United States: state-level analysis. *Am J Epidemiol* 2018;**187**: 2585–2595.
- Favre G, Pomar L, Musso D, Baud D. 2019-nCoV epidemic: what about pregnancies? *Lancet* 2020;**395**:e40.
- Gacci M, Coppi M, Baldi E, Sebastianelli A, Zaccaro C, Morselli S, Pecoraro A, Manera A, Nicoletti R, Liaci A *et al.* Semen impairment and occurrence of SARS-Cov-2 virus in semen after recovery of COVID-19. *Hum Reprod* 2021;**36**:1520–1529.
- Giattino C, Ritchie G, Roser M, Ortiz-Ospina E, Hasell J. *Excess Mortality during the Coronavirus Pandemic (COVID-19)*. Oxford, UK: Oxford Martin School, University of Oxford, 2021. www.ourworldindata.org (5 June 2021, date last accessed).
- Jing Y, Run-Qian L, Hao-Ran W, Hao-Ran C, Ya-Bin L, Yang G, Fei C. Potential influence of COVID-19/ACE2 on the female reproductive system. *Mol Hum Reprod* 2020;**26**:367–373.
- Kahn LG, Trasande L, Liu M, Mehta-Lee SS, Brubaker SG, Jacobson MH. Factors associated with changes in pregnancy intention among women who were mothers of young children in New York City following the COVID-19 outbreak. *JAMA Netw Open* 2021;**4**: e2124273.
- Leon DA, Shkolnikov VM, Smeeth L, Magnus P, Pechholdová M, Jarvis CI. COVID-19: a need for real-time monitoring of weekly excess deaths. *Lancet* 2020;**395**:e81.
- Lui B, Zheng M, White RS, Hoyler M. Economic burden of lives lost due to COVID-19 in New York State. *J Comp Eff Res* 2021;**10**: 893–897.
- Németh L, Jdanov DA, Shkolnikov VM. An open-sourced, web-based application to analyze weekly excess mortality based on the

- Short-term Mortality Fluctuations data series. *PLoS One* 2021;**16**: e0246663.
- Rasmussen SA, Smulian JC, Lednický JA, Wen TS, Jamieson DJ. Coronavirus disease 2019 (COVID-19) and pregnancy: what obstetricians need to know. *Am J Obstet Gynecol* 2020;**222**: 415–426.
- Sentilhes L, De Marcillac F, Jouffrieau C, Kuhn P, Thuet V, Hansmann Y, Ruch Y, Fafi-Kremer S, Deruelle P. Coronavirus disease 2019 in pregnancy was associated with maternal morbidity and preterm birth. *Am J Obstet Gynecol* 2020;**223**:914.e1–914.e15.
- Spiers GF, Kunonga TP, Beyer F, Craig D, Hanratty B, Jagger C. Trends in health expectancies: a systematic review of international evidence. *BMJ Open* 2021;**11**:e045567.
- Udry JR. The effect of the great blackout of 1965 on births in New York City. *Demography* 1970;**7**:325–327.
- Wang S, Zhou X, Zhang T, Wang Z. The need for urogenital tract monitoring in COVID-19. *Nat Rev Urol* 2020;**17**:314–315.
- Wilson N, Turner N, Baker MG. One hundred years ago in 1919: New Zealand's birth reduction shock associated with an influenza pandemic. *N Z Med J* 2019;**132**:57–62.