This is the peer reviewed version of the following article: **Impact of the COVID-19 pandemic on the circulation of other pathogens in England**, which has been published in final form at **https://doi.org/10.1002/jmv.28401**. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self-Archived Versions. This article may not be enhanced, enriched or otherwise transformed into a derivative work, without express permission from Wiley or by statutory rights under applicable legislation. Copyright notices must not be removed, obscured or modified. The article must be linked to Wiley's version of record on Wiley Online Library and any embedding, framing or otherwise making available the article or pages thereof by third parties from platforms, services and websites other than Wiley Online Library must be prohibited.

Impact of the COVID-19 pandemic on the circulation of other pathogens in England

Lauren J. Hayes[1#], Hannah Uri[1#], Denisa Bojkova[2], Jindrich Cinatl jr.[2,3], Mark N. Wass[1*], Martin Michaelis[1*]

[1] School of Biosciences, University of Kent, Canterbury CT2 7NJ, UK

[2] Institute for Medical Virology, University Hospital, Goethe University, Paul Ehrlich-Str. 40, 60596 Frankfurt am Main, Germany

[3] Dr. Petra Joh-Forschungshaus, Komturstr. 3A, 60528 Frankfurt am Main, Germany

[#] equal contribution

* Corresponding authors:

Mark Wass, School of Biosciences, University of Kent, Canterbury CT2 7NJ, UK; phone +44 1227 82 7626; e-mail M.N.Wass@kent.ac.uk
Martin Michaelis, School of Biosciences, University of Kent, Canterbury CT2 7NJ, UK; phone +44 1227 82 7804; e-mail M.Michaelis@kent.ac.uk

Data availability statement

All data are provided in the manuscript and its supplements.

Funding statement

This work was supported by the BBSRC via the SoCoBio DTP and the Frankfurter Stiftung für krebskranke Kinder.

Conflict of interest disclosure

Nothing to declare.

Author contributions

L.H. and M.M. developed the project idea. L.H. and H.U. performed the research. M.N.W. and M.M. supervised the research. All authors analysed data. M.M. wrote the initial manuscript draft. All authors contributed to the finalisation of the manuscript. All authors approved the final version of the manuscript.

Ethics approval statement

Not applicable.

Patient consent statement

Not applicable.

Permission to reproduce material from other sources

Not applicable.

Clinical trial registration

Not applicable.

Dear Editor,

Previous studies suggested that non-pharmaceutical interventions during the COVID-19 pandemic have also affected the spread of other pathogens [1-4]. Here, we analysed the transmission patterns of 22 infectious diseases in England in the context of the COVID-19 prevention measures, using data derived from the UK Health Security Agency, the UK Office for National Statistics, and the Royal College of General Practitioners Research and Surveillance Centre (Suppl. Methods, Suppl. Table 1, Suppl. Table 2).

Reported cases for all investigated infectious diseases dipped in response to the first lockdown except from methicillin-resistant *Staphylococcus aureus* (MRSA), Lyme disease, and hepatitis E (Figure 1, Suppl. Figures 1-22). MRSA infections are usually diagnosed in healthcare settings [5], and some studies reported an increase of MRSA cases during COVID-19 [5]. Hepatitis E is predominantly transmitted by contaminated food in England, in particular from farmed pigs [6]. Therefore, these finding do not seem to be surprising.

Lyme disease was not reduced during the initial lockdown but a decrease has been reported later in the pandemic (Figure 1, Suppl. Figure 22), which is probably attributed to underreporting [7,8]. Generally, the drop in documented cases during the first lockdown is difficult to interpret, as it might be the consequence of underreporting [7-9].

Thirteen diseases displayed a sustained reduction when prevention measures were in place (Figure 1, Suppl. Figures 1-22), including nine of the ten diseases that spread via the air and four of the six diseases characterised by faecal-oral transmission (Figure 1, Suppl. Figures 1-10 and 16-21).

The prevention measure-associated associated reduction of airborne pathogens confirms other findings [3,10]. The only exception was tuberculosis (Figure 1, Suppl. Figure 9). Most tuberculosis infections are asymptomatic and go undiagnosed [11,12]. Delayed diagnoses due to limited access to tuberculosis services during the pandemic may have caused a rise of severe cases, including COVID-19/ tuberculosis co-infections [12,13]. Hence, the pandemic measures may not have reduced severe tuberculosis cases, which are typically diagnosed.

Moreover, our findings agree with others showing that hygiene measures and physical distancing reduce the transmission of enteric diseases that are transmitted via the faecal-oral route [3,9,10,14,15]. Exceptions may indicate pathogens that are predominantly spread by food contaminations without significant further human-to-human transmission [6]. Also in agreement with previous findings [3], the pandemic-related prevention measures disrupted the seasonal transmission patterns of different infectious diseases (Figure 1; Suppl. Figures 1,2,6,7,20).

There are concerns that the disruption of routine vaccinations may affect population immunity resulting in larger outbreaks of vaccine-preventable diseases [3]. However, our findings indicate a sustainable suppression of vaccine-preventable diseases also beyond the lifting of restrictions (Figure 1). This included measles, mumps, rubella, pertussis, and pneumococcal disease (Suppl. Figures 3-6,10). Although our data also indicate a sustained reduction of influenza-like illnesses, other data suggest that influenza cases should be expected to rebound [16,17]. This may reflect the relatively low influenza vaccination rates and influenza vaccine efficacy compared to other vaccine-preventable diseases [18].

By contrast, non-vaccine preventable respiratory infections including chickenpox (not part of routine vaccinations in the UK), scarlet fever, and streptococcal

pharyngitis displayed an immediate resurgence after the removal of prevention measures (Suppl. Figures 1,7,8), suggesting that similar transmission peaks have been prevented by the vaccine-mediated immunity for the diseases with high vaccine coverage in the UK.

Concerns have been raised that a lack of exposure to common pathogens may result in decreased immunity enabling larger and more deleterious outbreaks [3]. However, only four infectious diseases (chickenpox, herpes simplex virus, Skin and Subcutaneous Tissue Infections, Infectious Intestinal Diseases) have since the removal of all restrictions in England on 19th July 2021 resulted in higher spread levels than pre-COVID-19 (Figure 1). It remains to be investigated whether these increases may be related to COVID-19.

In conclusion, our analysis shows that the COVID-19 prevention measures reduced the spread of pathogens that are transmitted via the air and the faecal-oral route. Despite concerns that a lack of exposure to common pathogens may affect population immunity and result in large outbreaks by various pathogens post-COVID-19, only four of the 22 investigated diseases and disease groups displayed higher post- than pre-pandemic levels without an obvious causative relationship. This included chickenpox for which an effective vaccine is available [19] but not used in the UK. Notably, the COVID-19 prevention measures resulted in the sustained suppression of vaccine-preventable infectious diseases also after the removal of restrictions, while non-vaccine preventable diseases displayed a rapid rebound, supporting the importance of effective vaccination programmes. More research investigating how disease burden can be reduced by tolerable non-pharmaceutical interventions is warranted.

References

1) Andrés P, Blandine P, Victoria D, William M, Justine O, Laurent E, Cedrine M, Bruno L, Aurelien T, Thomas J, Sophie TA, Manuel RC, Olivier T. Interactions between Severe Acute Respiratory Syndrome Coronavirus 2 Replication and Major Respiratory Viruses in Human nasal Epithelium. J Infect Dis 2022 Aug 29:jiac357. doi: 10.1093/infdis/jiac357.

2) Eldesouki RE, Uhteg K, Mostafa HH. The circulation of Non-SARS-CoV-2 respiratory viruses and coinfections with SARS-CoV-2 during the surge of the Omicron variant. J Clin Virol 2022;153:105215.

3) Oh KB, Doherty TM, Vetter V, Bonanni P. Lifting non-pharmaceutical interventions following the COVID-19 pandemic - the quiet before the storm? Expert Rev Vaccines. 2022 Sep 5:1-13. doi: 10.1080/14760584.2022.2117693.

4) Shi HJ, Kim NY, Eom SA, Kim-Jeon MD, Oh SS, Moon BS, Kwon MJ, Eom JS. Effects of Non-Pharmacological Interventions on Respiratory Viruses Other Than SARS-CoV-2: Analysis of Laboratory Surveillance and Literature Review From 2018 to 2021. J Korean Med Sci. 2022;37:e172.

5) Segala FV, Bavaro DF, Di Gennaro F, Salvati F, Marotta C, Saracino A, Murri R, Fantoni M. Impact of SARS-CoV-2 Epidemic on Antimicrobial Resistance: A Literature Review. Viruses 2021;13:2110.

6) Oeser C, Vaughan A, Said B, Ijaz S, Tedder R, Haywood B, Warburton F, Charlett A, Elson R, Morgan D. Epidemiology of Hepatitis E in England and Wales: A 10-Year Retrospective Surveillance Study, 2008-2017. J Infect Dis 2019;220:802-810.

7) McCormick DW, Kugeler KJ, Marx GE, Jayanthi P, Dietz S, Mead P, Hinckley AF. Effects of COVID-19 Pandemic on Reported Lyme Disease, United States, 2020. Emerg Infect Dis. 2021;27:2715-2717.

8) Piotrowski M, Rymaszewska A. The Impact of a Pandemic COVID-19 on the Incidence of Borreliosis in Poland. Acta Parasitol 2022;67:1007-1009.

9) Kim S, Kim J, Choi BY, Park B. Trends in gastrointestinal infections before and during non-pharmaceutical interventions in Korea in comparison with the United States. Epidemiol Health. 2022;44:e2022011.

10) Nielsen RT, Dalby T, Emborg HD, Larsen AR, Petersen A, Torpdahl M, Hoffmann S, Vestergaard LS, Valentiner-Branth P. COVID-19 preventive measures coincided with a marked decline in other infectious diseases in Denmark, spring 2020. Epidemiol Infect. 2022;150:e138.

11) Boom WH, Schaible UE, Achkar JM. The knowns and unknowns of latent Mycobacterium tuberculosis infection. J Clin Invest 2021;131:e136222.

12) Trajman A, Felker I, Alves LC, Coutinho I, Osman M, Meehan SA, Singh UB, Schwartz Y. The COVID-19 and TB syndemic: the way forward. Int J Tuberc Lung Dis 2022;26:710-719.

13) Wang Q, Guo S, Wei X, Dong Q, Xu N, Li H, Zhao J, Sun Q. Global prevalence, treatment and outcome of tuberculosis and COVID-19 coinfection: a systematic review and meta-analysis (from November 2019 to March 2021). BMJ Open 2022;12:e059396.

14) Knox MA, Garcia-R JC, Ogbuigwe P, Pita A, Velathanthiri N, Hayman DTS. Absence of Cryptosporidium hominis and dominance of zoonotic Cryptosporidium species in patients after Covid-19 restrictions in Auckland, New Zealand. Parasitology. 2021;148:1288-1292.

15) Lucero Y, Matson DO, Ashkenazi S, George S, O'Ryan M. Norovirus: Facts and Reflections from Past, Present, and Future. Viruses 2021;13:2399.

University of Kent

Kent Academic Repository

Hayes, Lauren J., Uri, Hannah, Bojkova, Denisa, Cinatl, Jindrich, Wass, Mark N. and Michaelis, Martin (2023) *Letter to the editor - Impact of the COVID-19 pandemic on the circulation of other pathogens in England.* Journal of Medical Virology, 95 (1). ISSN 0146-6615.

Downloaded from
https://kar.kent.ac.uk/100589/ The University of Kent's Academic Repository KAR

The version of record is available from
https://doi.org/doi:10.1002/jmv.28401

This document version
Author's Accepted Manuscript

DOI for this version
https://doi.org/10.22024/UniKent/01.02.100589.3364156

Licence for this version
UNSPECIFIED

Additional information
For the purpose of open access, the author(s) has applied a Creative Commons Attribution (CC BY) licence to any Author Accepted Manuscript version arising.

Versions of research works

Versions of Record
If this version is the version of record, it is the same as the published version available on the publisher's web site. Cite as the published version.

Author Accepted Manuscripts
If this document is identified as the Author Accepted Manuscript it is the version after peer review but before type setting, copy editing or publisher branding. Cite as Surname, Initial. (Year) 'Title of article'. To be published in ***Title of Journal*** , Volume and issue numbers [peer-reviewed accepted version]. Available at: DOI or URL (Accessed: date).

Enquiries
If you have questions about this document contact ResearchSupport@kent.ac.uk. Please include the URL of the record in KAR. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies).

16) Pérez-López A, Al Mana H, Iqbal M, Suleiman M, Hasan MR, Tang P. Resurgence of influenza A infections in children after the relaxation of COVID-19-related social distancing measures and normalization of international travel in Qatar. J Travel Med. 2022 Sep 23:taac107. doi: 10.1093/jtm/taac107.

17) Sominina A, Danilenko D, Komissarov A, Karpova L, Pisareva M, Fadeev A, Konovalova N, Eropkin M, Stolyarov K, Shtro A, Burtseva E, Lioznov D. Resurgence of Influenza Circulation in the Russian Federation during the Delta and Omicron COVID-19 Era. Viruses. 2022;14:1909.

18) Uyeki TM, Hui DS, Zambon M, Wentworth DE, Monto AS. Influenza. Lancet 2022;400:693-706.

19) Otani N, Shima M, Yamamoto T, Okuno T. Effect of Routine Varicella Immunization on the Epidemiology and Immunogenicity of Varicella and Shingles. Viruses 2022;14:588.

Figure legend

Figure 1. Impact of COVID-19 prevention measures on the circulation of other infectious diseases. Overview table providing a qualitative description of the impact of the COVID-19 measures on the investigated pathogens in England and curves illustrating the impact of the COVID-19 measures on hepatitis C, measles, and chickenpox. Detailed information is presented in the Suppl. Figures 1-22.