

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

3 Lauren Hayes<sup>1#</sup>, Hannah Uri<sup>1#</sup>, Denisa Bojkova<sup>2</sup>, Jindrich Cinatl jr.<sup>2,3</sup>, Mark N.  
4 Wass<sup>1\*</sup>, Martin Michaelis<sup>1\*</sup>

5 <sup>1</sup> School of Biosciences, University of Kent, Canterbury CT2 7NJ, UK

6 <sup>2</sup> Institute for Medical Virology, University Hospital, Goethe University, Paul Ehrlich-  
7 Str. 40, 60596 Frankfurt am Main, Germany

8 <sup>3</sup> Dr. Petra Joh-Forschungshaus, Komturstr. 3A, 60528 Frankfurt am Main, Germany

9

10 # equal contribution

11

12 \* Corresponding authors:

13 Mark Wass, School of Biosciences, University of Kent, Canterbury CT2 7NJ, UK;

14 phone +44 1227 82 7626; e-mail M.N.Wass@kent.ac.uk

15 Martin Michaelis, School of Biosciences, University of Kent, Canterbury CT2 7NJ,

16 UK; phone +44 1227 82 7804; e-mail M.Michaelis@kent.ac.uk

17 **Abstract**

18           The COVID-19 pandemic and the associated prevention measures did not  
19 only impact on the transmission of COVID-19 but also on the spread of other  
20 infectious diseases in an unprecedented natural experiment. Here, we analysed the  
21 transmission patterns of 22 different infectious diseases during the COVID-19  
22 pandemic in England. Our results show that the COVID-19 prevention measures  
23 generally reduced the spread of pathogens that are transmitted via the air and the  
24 faecal-oral route. Moreover, the COVID-19 prevention measures resulted in the  
25 sustained suppression of vaccine-preventable infectious diseases also after the  
26 removal of restrictions, while non-vaccine preventable diseases displayed a rapid  
27 rebound. Despite concerns that a lack of exposure to common pathogens may affect  
28 population immunity and result in large outbreaks by various pathogens post-COVID-  
29 19, only four of the 22 investigated diseases and disease groups displayed higher  
30 post- than pre-pandemic levels without an obvious causative relationship. Notably,  
31 this included chickenpox for which an effective vaccine is available but not used in  
32 the UK, which provides strong evidence supporting the inclusion of the chickenpox  
33 vaccination into the routine vaccination schedule in the UK. In conclusion, our  
34 findings provide unique, novel insights into the impact of non-pharmaceutical  
35 interventions on the spread of a broad range of infectious diseases.

36

37 Previous studies have suggested that non-pharmaceutical interventions  
38 during the COVID-19 pandemic have also affected the spread of other pathogens [1-  
39 4]. Here, we analysed the transmission patterns of 22 infectious diseases in England  
40 in the context of the COVID-19 prevention measures, using data derived from the UK  
41 Health Security Agency, the UK Office for National Statistics, and the Royal Collage  
42 of General Practitioners Research and Surveillance Centre (Suppl. Methods, Suppl.  
43 Table 1, Suppl. Table 2).

44 Reported cases for all investigated infectious diseases dipped in response to  
45 the first lockdown except from methicillin-resistant *Staphylococcus aureus* (MRSA),  
46 Lyme disease, and hepatitis E (Figure 1, Suppl. Figures 1-22). MRSA infections are  
47 usually diagnosed in healthcare settings [5], and some studies reported an increase  
48 of MRSA cases during COVID-19 [5]. Therefore, this finding does not seem to be  
49 surprising.

50 For Lyme disease, no reduction is seen in response to the initial lockdown but  
51 lower case numbers have been reported during the COVID-19 pandemic (Figure 1,  
52 Suppl. Figure 22), which is in line with other studies and commonly attributed to  
53 underreporting [6,7]. Generally, the initial drop in documented cases during the first  
54 lockdown is difficult to interpret, as it might be the consequence of underreporting [6-  
55 8].

56 Thirteen diseases displayed a sustained reduction during the time period  
57 when prevention measures were in place (Figure 1, Suppl. Figures 1-22). This  
58 included nine of the ten diseases that spread via the air and four of the six diseases  
59 that are characterised by faecal-oral transmission (Figure 1, Suppl. Figures 1-10 and  
60 16-21).

61

**Figure 1**

	Transmission	Vaccine	Sustained suppression	Resurgence	Compared to Pre-COVID-19	Seasonal patterns
Chickenpox	Airborne/ droplet	Yes*	Yes	Yes	Higher	Disrupted
Influenza-like illnesses	Airborne/ droplet	Yes**	Yes	Unclear	Lower	Disrupted
Measles	Airborne/ droplet	Yes	Yes	No	Lower	Not applicable
Mumps	Airborne/ droplet	Yes	Yes	No	Lower	Not applicable
Rubella	Airborne/ droplet	Yes	Yes	No	Lower	Not applicable
Pneumococcal disease	Airborne/ droplet	Yes	Yes	Yes	Lower	Disrupted
Scarlet fever	Airborne/ droplet	No	Yes	Yes	Comparable	Disrupted
Streptococcal pharyngitis/ strep throat	Airborne/ droplet	No	Yes	Yes	Comparable to lower	Potentially disrupted
Tuberculosis	Airborne/ droplet	No	No	No	Comparable	Not applicable
Pertussis/ whooping cough	Airborne/ droplet	Yes	Yes	No	Lower	Not applicable
Hepatitis C	Blood-borne	No	No	No	Comparable	Not applicable
Herpes simplex virus	Direct contact	No	No	No	Higher	Not applicable
Methicillin-resistant Staphylococcus aureus	Direct contact	No	No	No	Comparable	Not applicable
Skin and Subcutaneous Tissue Infections	Direct contact	No	No	No	Higher	Not applicable
Urinary tract infections	Direct contact	No	No	No	Comparable	Not applicable
Cryptosporidiosis	Faecal-oral	No	Yes	No	Comparable	Unaffected
Foodborne illness	Faecal-oral	No	Yes	No	Lower	Unaffected
Hepatitis E	Faecal-oral	No	No	No	Comparable	Not applicable
Infectious Intestinal Diseases	Faecal-oral	No	No	No	Higher	Not applicable
Norovirus	Faecal-oral	No	Yes	Yes	Comparable	Disrupted
Shigellosis	Faecal-oral	No	Yes	Yes	Comparable	Not applicable
Lyme disease	Vector	No	Yes	Unclear	Lower	Unaffected



62

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

68

69           The impact of the COVID-19 prevention measures on pathogens that are  
70 transmitted via the air is in agreement with other findings [3,9]. The only exception  
71 was tuberculosis (Figure 1, Suppl. Figure 9). However, most tuberculosis infections  
72 are asymptomatic and go undiagnosed [10,11]. During COVID-19, delayed  
73 diagnoses due to limited access to tuberculosis services have been suggested to  
74 have resulted in a rise of severe cases, including detrimental COVID-19/ tuberculosis  
75 co-infections [11,12]. Hence, it is plausible that the pandemic measures did not  
76 cause a reduction of severe tuberculosis cases, which are typically diagnosed.

77           Moreover, our findings are in line with others showing that hygiene measures  
78 and physical distancing reduce the transmission of (foodborne) enteric diseases that  
79 are transmitted via the faecal-oral route [3,8,9,13,14]. Also in agreement with  
80 previous findings [3], the COVID-19 pandemic and the related prevention measures  
81 disrupted the seasonal transmission patterns of different infectious diseases (Figure  
82 1; Suppl. Figures 1,2,6,7,20).

83           There are concerns that the disruption of routine vaccinations may result in a  
84 decreased population immunity and in turn larger outbreaks of vaccine-preventable  
85 infectious diseases [3]. However, our findings indicate a sustainable suppression of  
86 vaccine-preventable diseases also beyond the lifting of restrictions (Figure 1). This  
87 included measles, mumps, rubella, pertussis, pneumococcal disease, and influenza,  
88 as indicated by the number of influenza-like illnesses (although this category may  
89 include other respiratory diseases) (Suppl. Figures 2-6,10). By contrast, non-vaccine  
90 preventable respiratory infections including chickenpox (not part of routine  
91 vaccinations in the UK), scarlet fever, and streptococcal pharyngitis displayed an  
92 immediate resurgence after the removal of prevention measures (Suppl. Figures

93 1,7,8), suggesting that similar transmission peaks have been prevented by the  
94 vaccine-mediated immunity for the diseases with high vaccine coverage in the UK.

95 Concerns have also been raised about whether a lack of exposure to common  
96 pathogens may result in decreased immunity enabling larger and more deleterious  
97 outbreaks after the lifting of restrictions [3]. However, only four infectious diseases  
98 (chickenpox, herpes simplex virus, Skin and Subcutaneous Tissue Infections,  
99 Infectious Intestinal Diseases) have since the removal of all restrictions in England  
100 on 19<sup>th</sup> July 2021 resulted in spread levels that exceeded those commonly observed  
101 pre-COVID-19 (Figure 1), and it remains to be investigated whether the observed  
102 increases may be related to COVID-19.

103 In conclusion, our analysis of the transmission patterns of infectious diseases  
104 shows that the COVID-19 prevention measures reduced, in particular, the spread of  
105 pathogens that are transmitted via the air and the faecal-oral route. Moreover, the  
106 COVID-19 prevention measures resulted in the sustained suppression of vaccine-  
107 preventable infectious diseases also after the removal of restrictions, while non-  
108 vaccine preventable diseases displayed a rapid rebound, supporting the importance  
109 of effective vaccination programmes. Despite concerns that a lack of exposure to  
110 common pathogens may affect population immunity and result in large outbreaks by  
111 various pathogens post-COVID-19, only four of the 22 investigated diseases and  
112 disease groups displayed higher post- than pre-pandemic levels without an obvious  
113 causative relationship. This included chickenpox for which an effective vaccine is  
114 available [15] but not used in the UK.

115

116 **Data availability statement**

117 All data are provided in the manuscript and its supplements.

118 **Funding statement**

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

121 **Conflict of interest disclosure**

122 Nothing to declare.

123

## 124 **References**

- 125 1) Andrés P, Blandine P, Victoria D, William M, Justine O, Laurent E, Cedrine M,  
126 Bruno L, Aurelien T, Thomas J, Sophie TA, Manuel RC, Olivier T. Interactions  
127 between Severe Acute Respiratory Syndrome Coronavirus 2 Replication and Major  
128 Respiratory Viruses in Human nasal Epithelium. *J Infect Dis.* 2022 Aug 29;jiac357.  
129 doi: 10.1093/infdis/jiac357.
- 130 2) Eldesouki RE, Uhteg K, Mostafa HH. The circulation of Non-SARS-CoV-2  
131 respiratory viruses and coinfections with SARS-CoV-2 during the surge of the  
132 Omicron variant. *J Clin Virol.* 2022 Aug;153:105215. doi: 10.1016/j.jcv.2022.105215.
- 133 3) Oh KB, Doherty TM, Vetter V, Bonanni P. Lifting non-pharmaceutical interventions  
134 following the COVID-19 pandemic - the quiet before the storm? *Expert Rev*  
135 *Vaccines.* 2022 Sep 5:1-13. doi: 10.1080/14760584.2022.2117693.
- 136 4) Shi HJ, Kim NY, Eom SA, Kim-Jeon MD, Oh SS, Moon BS, Kwon MJ, Eom JS.  
137 Effects of Non-Pharmacological Interventions on Respiratory Viruses Other Than  
138 SARS-CoV-2: Analysis of Laboratory Surveillance and Literature Review From 2018  
139 to 2021. *J Korean Med Sci.* 2022 May 30;37(21):e172. doi:  
140 10.3346/jkms.2022.37.e172.
- 141 5) Segala FV, Bavaro DF, Di Gennaro F, Salvati F, Marotta C, Saracino A, Murri R,  
142 Fantoni M. Impact of SARS-CoV-2 Epidemic on Antimicrobial Resistance: A  
143 Literature Review. *Viruses.* 2021 Oct 20;13(11):2110. doi: 10.3390/v13112110.
- 144 6) McCormick DW, Kugeler KJ, Marx GE, Jayanthi P, Dietz S, Mead P, Hinckley AF.  
145 Effects of COVID-19 Pandemic on Reported Lyme Disease, United States, 2020.  
146 *Emerg Infect Dis.* 2021 Oct;27(10):2715-2717. doi: 10.3201/eid2710.210903.

- 147 7) Piotrowski M, Rymaszewska A. The Impact of a Pandemic COVID-19 on the  
148 Incidence of Borreliosis in Poland. *Acta Parasitol.* 2022 Jun;67(2):1007-1009. doi:  
149 10.1007/s11686-021-00495-0.
- 150 8) Kim S, Kim J, Choi BY, Park B. Trends in gastrointestinal infections before and  
151 during non-pharmaceutical interventions in Korea in comparison with the United  
152 States. *Epidemiol Health.* 2022;44:e2022011. doi: 10.4178/epih.e2022011.
- 153 9) Nielsen RT, Dalby T, Emborg HD, Larsen AR, Petersen A, Torpdahl M, Hoffmann  
154 S, Vestergaard LS, Valentiner-Branth P. COVID-19 preventive measures coincided  
155 with a marked decline in other infectious diseases in Denmark, spring 2020.  
156 *Epidemiol Infect.* 2022 Jul 28;150:e138. doi: 10.1017/S0950268822001145.
- 157 10) Boom WH, Schaible UE, Achkar JM. The knowns and unknowns of latent  
158 *Mycobacterium tuberculosis* infection. *J Clin Invest.* 2021 Feb 1;131(3):e136222. doi:  
159 10.1172/JCI136222.
- 160 11) Trajman A, Felker I, Alves LC, Coutinho I, Osman M, Meehan SA, Singh UB,  
161 Schwartz Y. The COVID-19 and TB syndemic: the way forward. *Int J Tuberc Lung*  
162 *Dis.* 2022 Aug 1;26(8):710-719. doi: 10.5588/ijtld.22.0006.
- 163 12) Wang Q, Guo S, Wei X, Dong Q, Xu N, Li H, Zhao J, Sun Q. Global prevalence,  
164 treatment and outcome of tuberculosis and COVID-19 coinfection: a systematic  
165 review and meta-analysis (from November 2019 to March 2021). *BMJ Open.* 2022  
166 Jun 20;12(6):e059396. doi: 10.1136/bmjopen-2021-059396.
- 167 13) Knox MA, Garcia-R JC, Ogbuigwe P, Pita A, Velathanthiri N, Hayman DTS.  
168 Absence of *Cryptosporidium hominis* and dominance of zoonotic *Cryptosporidium*  
169 species in patients after Covid-19 restrictions in Auckland, New Zealand.  
170 *Parasitology.* 2021 Sep;148(11):1288-1292. doi: 10.1017/S0031182021000974.

171 14) Lucero Y, Matson DO, Ashkenazi S, George S, O’Ryan M. Norovirus: Facts and  
172 Reflections from Past, Present, and Future. *Viruses*. 2021 Nov 30;13(12):2399. doi:  
173 10.3390/v13122399.

174 15) Otani N, Shima M, Yamamoto T, Okuno T. Effect of Routine Varicella  
175 Immunization on the Epidemiology and Immunogenicity of Varicella and Shingles.  
176 *Viruses*. 2022 Mar 12;14(3):588. doi: 10.3390/v14030588.

177

178