

1 **Widespread use of face masks in public may slow the spread of SARS CoV-2:**
2 **an ecological study**

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32 **Abstract**

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35 **Background**

36 The reasons for the large differences between countries in the sizes of their SARS
37 CoV-2 epidemics is unknown. Individual level studies have found that the use of face
38 masks was protective for the acquisition and transmission of a range of respiratory
39 viruses including SARS CoV-1. We hypothesized that population level usage of face
40 masks may be negatively associated SARS CoV-2 spread.

41

42 **Methods**

43 At a country level, linear regression was used to assess the association between
44 COVID-19 diagnoses per inhabitant and the national promotion of face masks in
45 public (coded as a binary variable), controlling for the age of the COVID-19 epidemic
46 and testing intensity.

47

48 **Results**

49 Eight of the 49 countries with available data advocated wearing face masks in public
50 – China, Czechia, Hong Kong, Japan, Singapore, South Korea, Thailand and
51 Malaysia. In multivariate analysis face mask use was negatively associated with
52 number of COVID-19 cases/inhabitant (coef. -326, 95% CI -601- -51, P=0.021).
53 Testing intensity was positively associated with COVID-19 cases (coef. 0.07, 95% CI
54 0.05-0.08, P<0.001).

55

56 **Conclusion**

57 Whilst these results are susceptible to residual confounding, they do provide
58 ecological level support to the individual level studies that found face mask usage to
59 reduce the transmission and acquisition of respiratory viral infections.

60

61 **Keywords:** SARS CoV-2; COVID-19; face masks; prevention; epidemiology; Asia

62 **Background**

63 SARS CoV-2, the viral cause of COVID-19, has spread rapidly to over 190 countries
64 [1]. There has, however, been remarkable variation in how extensively it has spread
65 and in the national responses to this spread [1, 2]. For example, although the virus is
66 thought to have first emerged in China, European countries such as Italy and Spain
67 have reported roughly 30-fold higher number of infections per capita than China [1,
68 2]. Understanding the reasons underpinning this heterogeneity in spread is crucial to
69 ongoing prevention efforts. The cornerstones of prevention efforts have included
70 extensive testing, contact tracing and isolation and various forms of social
71 distancing/quarantining [3, 4]. Whilst there have been important differences in how
72 these were implemented in different countries, arguably the most striking difference
73 in approach has been in the use of universal face masks in public. Whereas a
74 number of predominantly Asian countries have promoted this practice, the World
75 Health Organization (WHO) and most European and North American countries have
76 not promoted this strategy [5, 6]. The head of the Chinese Center for Disease
77 Control and Prevention has stated that the biggest mistake that Europe and the US
78 were making in tackling COVID-19 was their failure to promote the widespread usage
79 of face masks in public [7]. The WHO argues against universal face mask use
80 based on a lack of evidence to support the practice, as well as a concern that using
81 face masks will provide users with a false sense of security which may result in
82 poorer hand hygiene and hence increased transmission [3, 5, 8]. The US Centers for
83 Disease Control and Prevention does not recommend that people who are well wear
84 a face mask to protect themselves from respiratory diseases, including COVID-19
85 [5]. In fact, the US Surgeon General stated that facemasks “are not effective in

86 preventing (the) general public from catching coronavirus” and urged people to
87 stop buying face masks [5].

88

89 Advocates of universal usage of face masks point to four types of evidence. Firstly,
90 SARS CoV-1 and -2 are spread mainly through contact- and droplet- but also
91 through airborne-transmission [6, 9]. Detailed environmental and epidemiological
92 investigations from the large Amoy Gardens outbreak of SARS CoV-1 revealed that
93 airborne transmission played an important role in the outbreak [10, 11]. Likewise in
94 vitro studies demonstrate that SARS CoV-2 can be aerosolized and remain viable in
95 the air in this form for at least 3 hours [12]. Although viral viability was not assessed,
96 air samples from hospital rooms and toilets used by COVID-19 patients as well as
97 from a crowded entrance to a department store tested positive for SARS CoV-2 [13].
98 Even if we discount the evidence of airborne transmission, face masks could play a
99 major role in reducing droplet and possibly contact (via reduced digital-oral
100 interactions) transmission. The second type of evidence is that from epidemiological
101 studies showing that masks do provide this protective effect. One systematic review
102 on the efficacy of face masks to prevent influenza, found evidence that face masks
103 were effective in preventing the transmission to others and weaker evidence that
104 they prevented influenza acquisition [14]. Likewise, a systematic review and
105 metanalysis in health care workers found that mask wearing was associated with a
106 lower incidence of clinical respiratory infections [15]. A Cochrane review of different
107 physical measures to prevent the acquisition of respiratory viruses found face masks
108 to be the most effective of all measures investigated - including social distancing
109 [16]. The results were similar for studies limited to SARS CoV-1 transmission, with
110 the authors concluding: ‘wearing a surgical mask or a N95 mask is the measure with

111 the most consistent and comprehensive supportive evidence' [16]. Thirdly, there is
112 increasing evidence that a large proportion of SARS CoV-2 transmission occurs from
113 pauci- or asymptomatic individuals. An estimated 30% of infections are truly
114 asymptomatic and 80% mild infections [17]. Evidence is also mounting that infected
115 individuals are infectious prior to the onset of symptoms [18]. Taken together these
116 findings provide an explanation for why epidemiological studies have found that
117 nondocumented infections were the infection source for 79% of documented cases
118 in Wuhan, China [18]. In this setting limiting masks to confirmed infections is far less
119 likely to have an impact on transmission than universal use. The key argument for
120 universal use is thus preventing transmission and a secondary argument is
121 preventing acquisition [7, 9].

122

123 These considerations provided the motivation for the current analysis where we
124 assessed if there was ecological level evidence that countries that promoted face
125 mask usage in public had a lower number of COVID-19 diagnoses per capita.

126

127 **Methods**

128 ***Dependent variable:***

129 The *cumulative number of cases of COVID-19* infection per million inhabitants on 29
130 March 2020 per country. This data was obtained from the European Centre for
131 Disease Prevention and Control (ECDC) data repository:
132 <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

133

134 ***Independent variables:***

135 *Universal face mask.* A binary variable equal to 1 or 0 according to whether or not
136 national policies promote the wearing of face masks in public regardless of
137 symptoms. Countries were classified according to a narrative review of official
138 national documents and other sources (STable 1).

139

140 *Testing intensity.* Cumulative number of nucleic acid amplification SARS CoV-2 tests
141 conducted per country per million inhabitants up till 29 March 2020. This data was
142 extracted from the Wikipedia COVID-19 testing site on 29 March 2020:
143 https://en.wikipedia.org/wiki/COVID-19_testing

144

145 *Age of epidemic.* The date the first case of COVID-19 was diagnosed in each
146 country. This was measured in days after the first COVID-19 case was officially
147 reported in China (10 January 2020). This data was obtained from the ECDC data
148 repository on 29 March 2020: [https://www.ecdc.europa.eu/en/geographical-](https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases)
149 [distribution-2019-ncov-cases](https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases)

150

151 ***Data analysis***

152 Linear regression was used to analyze the association between the independent and
153 dependent variables. We controlled for the fact that SARS CoV-2 epidemic is at
154 different stages in different countries via two methods. Firstly, the 'age of the
155 epidemic' variable was included in all analyses. Secondly, we only included countries
156 with at least 500 cumulative cases and countries whose first case was reported
157 before 7 March 2020. Countries with missing data were dropped from the analyses.
158 The analysis was performed in STATA version 16 (Stata Corp, College Station, Tx).
159 Although Hong Kong is a part of China it was included as a separate data point in

160 keeping with its population size and relative autonomy as regards public health
161 responses. Because Czechia was the only country to introduce universal face masks
162 late in the epidemic (18 March 2020), we repeated the analyses excluding Czechia
163 [19, 20].

164

165 **Results**

166 Forty-nine countries were found with complete data, epidemics older than 7 March
167 2020 and more than 500 cases/million inhabitants (STable 1). Large variations were
168 evident in the number of COVID-19 cases per million inhabitants (median 158,
169 interquartile range [IQR] 20-486), testing per million (median 1723, IQR 307-4802)
170 and the date of the first case (median 24 February, IQR 28 January – 28 February;
171 STable 1). Only 8 of these countries advocated wearing face masks in public –
172 China, Czechia, Hong Kong, Japan, Singapore, South Korea, Thailand and
173 Malaysia. These countries tended to have older epidemics. Seven of the 8 were in
174 the group of countries with the 10 oldest epidemics (STable 1).

175

176 In multivariate analysis face mask use was negatively associated with number of
177 COVID-19 cases (coef. -326, 95% CI -601- -51, $P=0.021$; Table 1). Testing intensity
178 was positively associated with COVID-19 cases (coef. 0.07, 95% CI 0.05-0.08,
179 $P<0.001$).

180

181 Repeating the analyses excluding Czechia strengthened the association between
182 COVID-19 cases and face mask usage slightly (STable 2).

183

184 **Discussion**

185 In this ecological study we found that countries that promoted widespread face mask
186 usage had lower cumulative numbers of COVID-19 diagnosed after controlling for
187 testing intensity and age of the epidemic. It is important to note that this association
188 may be entirely explained by unmeasured confounders. For example, if countries
189 promoting universal face masking also conducted more effective contact tracing and
190 isolation than other countries and this was responsible for the slower spread, our
191 study design would have falsely attributed this effect to using face masks. We did not
192 have accurate data to control for these confounders. We did however control for
193 testing intensity which is an important potential confounder. We also controlled for
194 the age of the epidemic which is an obvious independent determinant of the size of
195 the epidemic. A further limitation of our study was that we were unable to quantitate
196 the intensity of face mask use per country. This resulted in a rather crude binary
197 classification of face mask usage per country.

198

199 At this albeit early phase of the pandemic it is important to explore why the virus has
200 spread more extensively in many European countries than China and neighboring
201 countries where the outbreak appeared to have commenced. This is difficult in the
202 absence of data that quantitates national competency in terms of the various
203 components of successful national COVID-19 response plans. Narrative reviews of
204 the features that resulted in the success of countries such as China, Hong Kong,
205 Japan, Singapore and Taiwan have noted a number of common features. These
206 include: rapid response, extensive testing, contact isolation and the widespread
207 usage of face masks in public [4, 21].

208

209 There are a number of countries in Western European such as Italy that have
210 conducted intensive screening, contact tracing, isolation, social distancing and
211 widespread lockdowns and yet have amongst the largest COVID-19 epidemics in the
212 world [2]. A striking omission from this response-list if we compare it to the
213 responses in China and other Asian countries with lower COVID-19 incidence is that
214 the widespread use of face masks in public was not promoted. The only European
215 country to adopt this strategy was Czechia, and it did so at a relatively late stage in
216 the epidemic [19, 20]. Early indications suggest that despite higher testing rates than
217 the average for western European countries, the number of new infections is lower in
218 Czechia [1]. Future studies will however be crucial to evaluate the impact of this
219 intervention in Czechia and elsewhere. These studies may benefit from including
220 data from Taiwan and Macau where use of face masks in public has been high and
221 the cumulative number of infections has remained so low that they did not meet the
222 500 case threshold for inclusion in this study (Taiwan 283 and Macau 34 cumulative
223 cases as of 29 March) [1].

224

225 It is likely that a single intervention is not sufficient to suppress the spread of COVID-
226 19 [2]. The safest approach in the middle of this epidemic may be to introduce the
227 full package of interventions that have been proven to work in Asian countries and
228 then scale back according to new findings [3, 9]. Our analysis provides further
229 evidence that this package should include widespread usage of face masks in public.
230 Currently the only European country that can be considered to be doing this is
231 Czechia.

232

233 **Authors' contributions**

234 CK conceptualized the study, was responsible for the acquisition, analysis and
235 interpretation of data and wrote the analysis up as a manuscript.

236

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238 Nil

239

240 **Conflict of interest**

241 The author declares that he/she has no competing interests.

242

243 **Ethical approval**

244 The analysis involved a secondary analysis of public access ecological level data. As
245 a result, no ethics approval was necessary.

246

247 **Informed consent**

248 Not applicable

249 **Acknowledgements**

250 Nil

251

252 Table 1. Country level, multivariate linear regression of factors associated with
253 cumulative number of COVID-19 diagnoses per million inhabitants (N=49).

254

	Coef.	95% CI	P-value
Testing intensity	0.069	0.05-0.08	<0.001
Face masks	-326	-601 - -51	0.021
Date of epidemic	-3.59	-9.31 – 2.11	0.211

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