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.

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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.

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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).

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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

Background

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

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86   preventing (the) general public from catching coronavirus" and urged people to

87   stop buying face masks [5].

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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

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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).

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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

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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-

149   distribution-2019-ncov-cases

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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].

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165   **Results**

166   Forty-nine countries were found with complete data, epidemics older than 7 March

167   2020 and more that 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).

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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).

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181   Repeating the analyses excluding Czechia strengthened the association between

182   COVID-19 cases and face mask usage slightly (STable 2).

183

184   **Discussion**

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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.

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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].

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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.

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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

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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

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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).

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	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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