



RESEARCH ARTICLE

REVISED **COVID-19: Identifying countries with indicators of success in responding to the outbreak [version 2; peer review: 2 approved]**

David S. Kennedy ^{1,2}, VK Vu³, Hannah Ritchie^{4,5}, Rebecca Bartlein⁶,
Oliver Rothschild⁶, Daniel G. Bausch^{1,7}, Max Roser^{4,5}, Anna C. Seale ^{1,2}

¹UK-Public Health Rapid Support Team, London School of Hygiene & Tropical Medicine/ Public Health England, London, UK

²Department of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London, UK

³The Bill & Melinda Gates Foundation, Seattle, USA

⁴Our World in Data, Oxford, UK

⁵Oxford Martin School, University of Oxford, Oxford, UK

⁶Gates Ventures, Seattle, USA

⁷Department of Infectious and Tropical Diseases, London School of Hygiene & Tropical Medicine, London, UK

V2 **First published:** 18 Jun 2020, 4:62
<https://doi.org/10.12688/gatesopenres.13140.1>
Latest published: 29 Sep 2021, 4:62
<https://doi.org/10.12688/gatesopenres.13140.2>

Abstract

Background: In designing responses to the COVID-19 pandemic, it is critical to understand what has already worked well. We aimed to identify countries with emerging success stories from whom policymakers might draw important lessons.

Methods: We developed a process to first include countries with large enough populations that results were unlikely to be due to chance, that had sufficient cases for response mechanisms to be tested, and that shared the necessary publicly available data. Within these countries, we looked at indicators suggesting success in terms of detecting disease, containing the outbreak, and treating those who were unwell. To support comparability, we measured indicators per capita (per million) and across time. We then used the indicators to identify three countries with emerging success stories to include some diversity in global region, population demographics and form of government.

Results: We identified 66 countries that met our inclusion criteria on 18th May 2020. Several of these countries had indicators of success against the set indicators at different times in the outbreak. Vietnam had high levels of testing and successful containment with no deaths reported. South Korea had high levels of testing early in the outbreak, supporting containment. Germany had high levels of sustained testing and slower increases in cases and deaths than seen in other comparable settings.

Conclusions: At the time of our assessment, Vietnam and South Korea

Open Peer Review**Reviewer Status**

	Invited Reviewers	
	1	2
version 2 (revision) 29 Sep 2021	 report	 report
	↑	↑
version 1 18 Jun 2020	 report	 report

1. **Richard A. Kock** , Royal Veterinary College, London, UK

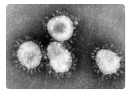
2. **Flavio Codeco Coelho** , Fundação Getulio Vargas, Rio de Janeiro, Brazil
University of Geneva, Geneva, Switzerland

Any reports and responses or comments on the article can be found at the end of the article.

were able to contain the outbreak of COVID-19 and avoid the exponential growth in cases seen elsewhere. Germany had more cases and deaths, but was nevertheless able to contain and mitigate the outbreak. Despite the many limitations to the data currently available, looking at comparative data can help identify countries from whom we can draw lessons, so that countries can inform and adapt their strategies for success in response to COVID-19.

Keywords

COVID-19, pandemic, lessons, exemplars, outbreak, response, learning



This article is included in the [Coronavirus \(COVID-19\)](#) collection.

Corresponding author: Anna C. Seale (anna.seale@lshtm.ac.uk)

Author roles: **Kennedy DS:** Investigation, Methodology, Writing – Original Draft Preparation, Writing – Review & Editing; **Vu V:** Conceptualization, Methodology, Project Administration, Writing – Review & Editing; **Ritchie H:** Data Curation, Investigation, Methodology, Software, Visualization, Writing – Review & Editing; **Bartlein R:** Conceptualization, Supervision, Writing – Review & Editing; **Rothschild O:** Conceptualization, Methodology, Project Administration, Writing – Review & Editing; **Bausch DG:** Conceptualization, Methodology, Writing – Review & Editing; **Roser M:** Conceptualization, Data Curation, Funding Acquisition, Methodology, Supervision, Writing – Review & Editing; **Seale AC:** Conceptualization, Formal Analysis, Methodology, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: Our World In Data is supported by The Bill and Melinda Gates Foundation (OPP1179119). ACS is funded by The Wellcome Trust (205184). The UK Public Health Rapid Support Team is funded by UK Aid from the Department of Health and Social Care and is jointly run by Public Health England and the London School of Hygiene & Tropical Medicine. The University of Oxford and King's College London are academic partners. The views expressed in this publication are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research or the Department of Health and Social Care.

Copyright: © 2021 Kennedy DS *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Kennedy DS, Vu V, Ritchie H *et al.* **COVID-19: Identifying countries with indicators of success in responding to the outbreak [version 2; peer review: 2 approved]** Gates Open Research 2021, 4:62 <https://doi.org/10.12688/gatesopenres.13140.2>

First published: 18 Jun 2020, 4:62 <https://doi.org/10.12688/gatesopenres.13140.1>

REVISED Amendments from Version 1

The manuscript has been revised to reflect both the Reviewers' comments.

Specifically, in the discussion, the language has been made more specific, in terms of the probable zoonic origins of recently emerged coronaviruses, as opposed to their being zoonoses.

Later in the discussion, in response to the comments, and whilst recognising the importance of modelling, we have indicated that the assessment has not included modelling of disease, and given the reasons for this.

Any further responses from the reviewers can be found at the end of the article

Introduction

A cluster of cases of pneumonia of unknown aetiology were identified in December 2019 in Wuhan, China¹. These cases were found to be caused by a novel coronavirus, SARS-CoV-2. The outbreak of coronavirus disease 2019 (COVID-19) continued, and with cases identified across the world, the outbreak was declared a Public Health Emergency of International Concern by the World Health Organization (WHO) on January 30th, 2020². At that time, there were 7,711 confirmed cases and 170 deaths in China, then the epicentre. Outside of China, 83 cases had been reported in 18 countries, with community transmission reported in three of these countries³. Further spread led to the declaration of a pandemic on March 11th, 2020. By the end of April 2020, there were over 3 million cases and over 200,000 deaths reported in 213 countries, areas or territories².

In mid-March the WHO Strategic and Technical Advisory Group for Infectious Hazards recommended that “all countries should consider a combination of response measures: case and contact finding; containment or other measures that aim to delay the onset of patient surges where feasible; and measures such as public awareness, promotion of personal protective hygiene, preparation of health systems for a surge of severely ill patients, stronger infection prevention and control in health facilities, nursing homes, and long-term care facilities, and postponement or cancellation of large-scale public gatherings.”⁴ Preparedness to support these activities, and the strategies used, have varied. Whilst recognising that different contexts require different approaches⁵, we aimed to develop criteria to identify countries that have limited the impact of COVID-19 as “success stories” with valuable lessons to share to other countries.

Methods

We assembled a group with expertise in public health policy, infectious diseases, outbreak response, and data analytics to develop a process to identify countries with emerging success in their response to COVID-19.

Countries from which others can potentially learn

To be considered as an emerging success in our analysis, we only included countries meeting three key criteria. Firstly, to ensure that results in indicators were unlikely to be due to

chance, and generalisable, we only included countries with populations over 5 million people. Secondly, we wanted to include countries with sufficient cases to demonstrate success, whilst recognizing that in some countries, low prevalence may be the result of effective containment, so we only included countries which had had at least 100 confirmed cases 21 days before our analysis. Thirdly, although data on COVID-19 cases and deaths are widely available, data on testing are less so and these data are essential to our analysis across the detect, contain, and treat phases, so we only included countries publishing testing data.

We used these three criteria as a first filter to identify countries with emerging success from all countries worldwide. Data were extracted on 18th May 2020, from those curated by *Our World In Data* (<https://ourworldindata.org/coronavirus>), based on daily published figures of cases and deaths from the European Centre for Disease Control. Population adjustments for per capita comparisons were made based on population data from the United Nations Population Division⁶. The database on testing was curated by Our World in Data based on information from public sources, including official websites, in press releases and by social media accounts of national authorities—usually governments, ministries of health, or centres for disease control⁷.

Countries with indicators of success in response to COVID-19

We then considered indicators which could reflect successful interventions to COVID-19. The [Global Health Security Index](#) (GHSI) is a tool to assess countries' health security, considering broad risks as well as geopolitical considerations, the health system, and whether the capacity to contain outbreaks has been tested⁸. It describes six categories: prevention, detection, rapid reporting, health system, compliance with international norms, and risk environment. Because transmission of COVID-19 is ongoing, it is too soon to determine if any country will ultimately succeed at prevention, so we excluded the prevention phase from our analysis and focused on three categories: detect, contain and treat. We cross-referenced these three categories to key actions from the WHO's “Strategic preparedness and response plan for the novel coronavirus” and then, based on the key actions, we selected indicators specific to COVID-19 that could be used to assess success in a country's response ([Table 1](#))⁹.

Principles for comparison

In doing this, we followed some general principles to ensure fair comparisons could be made between countries. Firstly, we used per capita indicators to account for the country's population. Secondly, we primarily used absolute dates (calendar dates) instead of relative dates (for example the number of days since a certain number of deaths), reflecting the fact that all countries were aware of events worldwide at the same time.

Detect. Testing strategies may differ during an outbreak. For example, when there are fewer cases and the aim is to contain the outbreak by contact tracing, a high number of tests per case may increase the chance of successful containment. If the outbreak has progressed to widespread community transmission and

Table 1. Indicators for evaluating country performance cross referenced against the Global Health Security Index, WHO response pillars and the phases of response.

GHSI	Response phase ¹⁰	Key actions	WHO Pillars	Indicators	Exemplars
Prevent	Prepare		1,5		
Detect	Contain	Detection of cases	1,4,5 1,3,4	Total COVID-19 tests per 1,000 people Number of COVID-19 tests per confirmed case Total COVID-19 tests vs. Confirmed deaths per million people	Detect
Respond	Contain	Isolation of suspected cases, contact tracing	1,6,7	Total confirmed COVID-19 cases per million people Total confirmed COVID-19 cases per million vs. Doubling time of total confirmed cases (7-day period) Total confirmed COVID-19 deaths per million people Total confirmed COVID-19 deaths per million vs. Doubling time of confirmed deaths (7-day period),	Contain
Healthcare	Mitigate	Case management Health care capacity	1,7,8	Case-fatality rate of the ongoing COVID-19 pandemic Total confirmed COVID-19 deaths vs. cases	Treat

WHO Pillars

- Pillar 1 - Country level coordination, planning, monitoring
 - Pillar 2 – Risk communication and community engagement
 - Pillar 3 - Surveillance, Rapid Response Teams, And Case Investigation
 - Pillar 4 - Points of Entry
 - Pillar 5 – National laboratories
 - Pillar 6 - Infection Prevention and Control
 - Pillar 7 - Case Management
 - Pillar 8 - Operational Support and Logistics
- GHSI=Global Health Security Index; WHO=World Health Organization

it is not feasible to trace all contacts of positive cases, then high levels of testing may not be as critical for community control. In this situation, in many places, population-wide restrictions are in place to reduce spread across the population rather than specifically targeting contacts of confirmed cases. There are many challenges with counting cases, not least because this will depend on the availability of testing and the ability to detect those with no or mild symptoms⁹. Counting and detecting deaths is likely to be a more accurate measure of the spread of the infection than cases. Based on these considerations, we defined key indicators for the “Detect” phase as **i) the number of tests per capita against time, ii) the number of tests per confirmed case, and iii) the number of tests per confirmed death with COVID-19 per capita.**

Contain. Although identifying people with COVID-19 depends on a country’s testing strategy and testing capacity, relative to its population, we felt that review of case data was still important. Case doubling time may be less affected by testing capacity

than case per capita, as long as testing capacity has not changed substantially or is at its maximum. However, as testing capacity has indeed changed over time, which may be reflected in an increase in cases, we also included deaths in our indicators for the “Contain” phase, since these are likely to have been tested and recorded more completely than cases. We included people with confirmed COVID-19 infection (cases) as an outcome in terms of **iv) confirmed cases per capita against time** and **v) confirmed cases per capita compared to confirmed case doubling time (7-day period)**, and people with confirmed death from COVID-19 in terms of **vi) confirmed COVID-19 deaths per capita** and **vii) confirmed COVID-19 deaths per capita compared to confirmed death doubling time (7-day period).**

Treat. There are many reporting biases when calculating the case fatality rate (CFR)^{11,12}. For example, the number of cases (denominator) will depend on the number of tests being done in total, and who is being tested. Countries testing many people, or which include those who are asymptomatic or mildly ill (an

infection fatality rate), will appear to have a lower CFR than countries testing only those who seek health care or are hospitalised, for example. There is also a delay between when people are infected and when they die. In countries going towards the epidemic peak, CFR will be underestimated because many people who will eventually die are still in the community or are hospitalised with severe infection¹³. There are also true demographic differences; countries with older populations or a high proportion of comorbidities have more people vulnerable to severe disease, and thus higher CFRs may be due to this, rather than inadequate treatment^{14,15}. While recognising these issues, we selected indicators to assess efforts to limit the number of deaths relative to the number of cases detected and how these changed over time; **viii) case fatality rate over time and ix) confirmed COVID-19 deaths compared to cases.**

Countries representing diverse regions and key intrinsic factors

We examined the countries that met our inclusion criteria against each of the nine indicators at specific time points (i.e., fixed calendar dates) to reflect, for example, countries with high testing capacity early on in the outbreak (January and February 2020), and countries moving through the phases of the outbreak. From this shortlist, we selected three countries with emerging success stories, also reflecting diverse geographic regions and varied intrinsic factors such as land and sea borders and differing political structures. This final decision for selection was to support learning from these countries relevant to as many other countries as possible.

Results

Countries from which others can potentially learn

On May 18th 2020, 123 countries met the population size criterion (Figure 1a), 98 met the total number of cases criterion (Figure 1b) and 66 reported testing data (Figures 1c). Although all African countries have reported cases of COVID-19, few have yet reached 21 days since their 100th confirmed case and even fewer are reporting testing data so the continent is under-represented in this analysis.

Identifying countries with indicators of success

Detect. We looked at total COVID-19 tests per 1,000 people against time, number of COVID-19 tests per confirmed case and total COVID-19 tests against confirmed deaths per million people (Figure 2). South Korea had high testing per confirmed case during January and February 2020, as did the United Kingdom. Capacity in South Korea continued to increase (Figure 2a), but Germany had higher capacity than both South Korea and the UK in mid-March, as Europe was declared the COVID-19 epicentre. Germany's testing continued to rapidly increase, from 7 to 29 tests per million people by the end of April. South Korea also had a high ratio of tests to confirmed cases early in the outbreak, decreasing as large clusters of infection developed during early March. In early May, Vietnam, was performing very strongly in terms of the number of tests per confirmed case (Figure 2b). Australia also had high levels of testing, and when Australia recorded its first COVID-19 death, it had conducted 5,610 tests per million people, the highest among countries meeting our criteria (Figure 2c).

Contain. We looked at total confirmed COVID-19 cases per million people, confirmed COVID-19 cases per million against doubling time of total confirmed cases (7-day period), confirmed COVID-19 deaths per million people against time and confirmed COVID-19 deaths per million against doubling time of confirmed deaths (7-day period) (Figure 3).

South Korea and Australia had very low cases of COVID-19 per capita (215 cases per million and 276 cases per million, respectively) compared to the rest of the world, but Vietnam was even lower, with only 3 cases per million (Figure 3a). Cases have peaked at different times worldwide, and as the number of new cases begins to reduce across Europe and North America (April/May 2020), other countries are seeing rapid increases in confirmed cases, for example Brazil (Figure 3a). For deaths, similar patterns emerge; Vietnam has not recorded any deaths with COVID-19 while South Korea and Australia have low numbers of deaths per capita compared to the rest of the world. This is in contrast to many European countries, with Belgium reporting the highest number of deaths per million people (786) (Figure 3b). Some of the countries recording a very high number of deaths from COVID-19 have passed the peak cases and doubling times for deaths are increasing, for example in Italy. (Figure 3c).

Treat. We looked at total confirmed COVID-19 deaths compared to cases, and case fatality rate (CFR) against time (Figure 4). South Korea reported only 263 deaths from 11,065 cases, a CFR of 2.4%. Germany reported substantially more deaths (7,935) and cases (174,697), a CFR of 4.5%, below the global average of 6.7%. Neither country had an apparent rapid increase in CFR seen in several other countries. These increases may be caused by an inaccurate denominator for CFR due to low testing capacity in relation to increasing cases (Figure 4a). South Korea and Australia have limited cases and deaths as shown in Figure 4b. While there are limitations to assessing the CFR in COVID-19¹⁶, the high levels of testing in South Korea and Germany will increase accuracy compared to settings with lower testing.

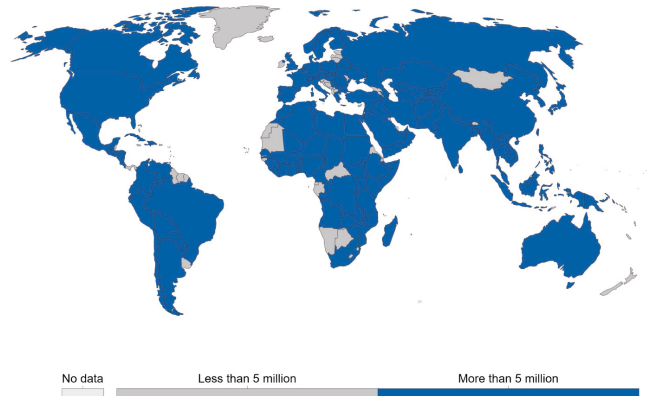
Overall. Several countries have indicators of success and as the pandemic continues to evolve, success will be found in other countries. Through the process we applied, we identified Vietnam, South Korea, and Germany as three countries with emerging success stories. Vietnam has had high levels of testing and effective containment¹⁷. South Korea has also had high levels of testing and effective containment. Whilst Germany had a relatively large outbreak compared to South Korea and Vietnam, the number of cases and deaths per capita rose more slowly than other more similar European countries, and not to the same heights, suggesting success across detection, containment and treatment.

Conclusions

We developed selection criteria to identify countries with indicators of success across current activities in relation to the COVID-19 outbreak. Several countries performed strongly in and across the three phases of detect, contain and treat. We identified Vietnam, South Korea and Germany as countries with

1a

Criteria 1: Population greater than 5 million



Source: UN World Population Prospects (2019)

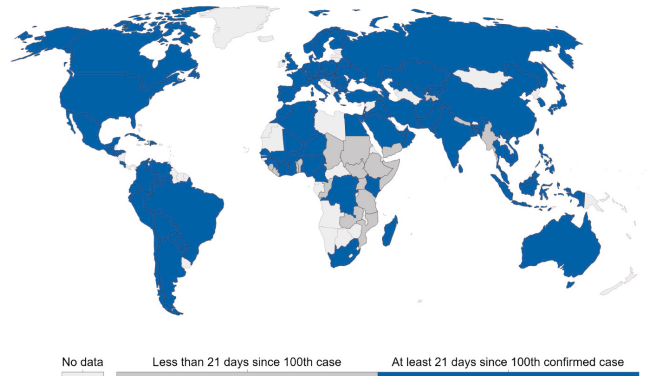
CC BY

1b

Criteria 2: at least 21 days since the 100th confirmed case, May 6, 2020



Highlighted are countries which meet two criteria:
1) Population greater than 5 million
2) More than 21 days since the 100th confirmed case



Source: European CDC – Situation Update Worldwide – Last updated 18th May, 11:00 (London time)

CC BY

1c

Criteria 3: also publishes COVID-19 testing data, May 6, 2020



Highlighted are countries which meet three key criteria for analysis:
1) Population greater than 5 million
2) More than 21 days since the 100th confirmed case
3) Publishes COVID-19 testing data



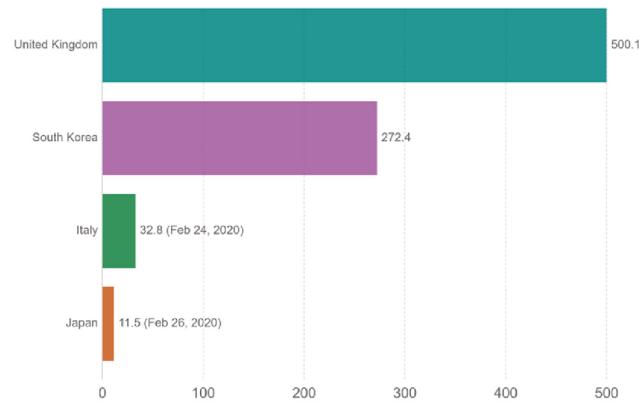
Source: European CDC – Situation Update Worldwide – Last updated 18th May, 11:00 (London time)

CC BY

Figure 1. Countries assessed in this study. These world maps show countries with **a)** populations over 5 million people, **b)** at least 100 confirmed people with COVID-19 21 days prior to assessment and **c)** published testing data. Updated graphs can be found [here](#), [here](#) and [here](#).

2a

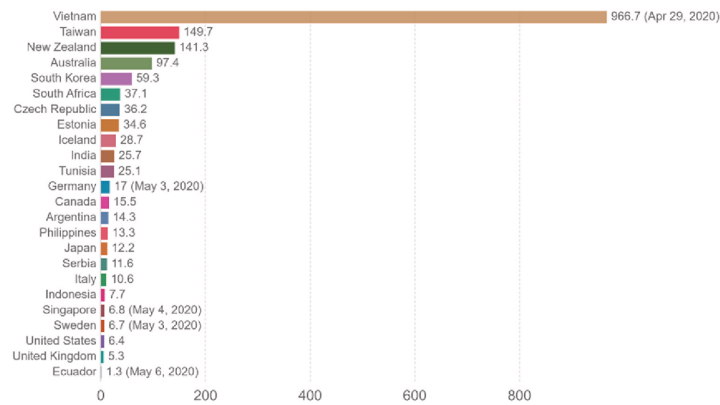
Number of COVID-19 tests per confirmed case, Feb 17, 2020



Source: Tests: official data collated by Our World in Data. Confirmed cases: European CDC – Situation Update Worldwide
 Note: For testing figures, there are substantial differences across countries in terms of the units, whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at the linked page.
 OurWorldInData.org/coronavirus • CC BY

2b

Number of COVID-19 tests per confirmed case, May 5, 2020

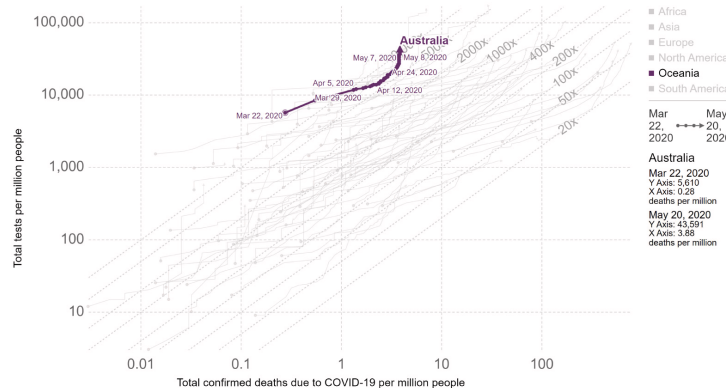


Source: Tests: official data collated by Our World in Data. Confirmed cases: European CDC – Situation Update Worldwide
 Note: For testing figures, there are substantial differences across countries in terms of the units, whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at the linked page.
 OurWorldInData.org/coronavirus • CC BY

2c

Per capita: COVID-19 tests vs. Confirmed deaths

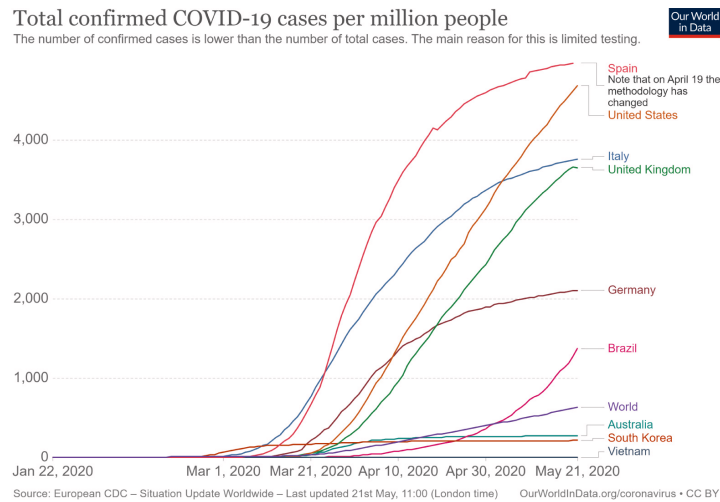
Both measures are shown per million people of the country's population.



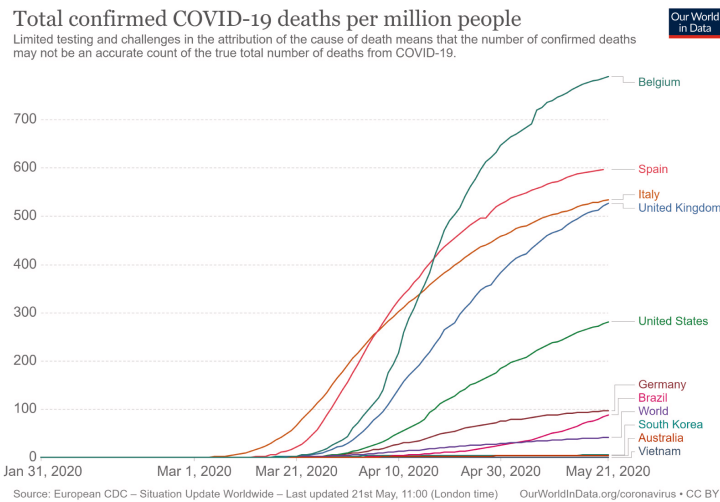
Source: Tests: official data collated by Our World in Data. Confirmed cases: European CDC – Situation Update Worldwide
 Note: For testing figures, there are substantial differences across countries in terms of the units, whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at the linked page.
 OurWorldInData.org/coronavirus • CC BY

Figure 2. Detect. These graphs show **a**) total COVID-19 tests per 1,000 people **b**) number of COVID-19 tests per confirmed case of COVID-19 **c**) total COVID-19 tests compared to confirmed deaths with COVID-19 per million people. Updated graphs can be found [here](#), [here](#) and [here](#).

3a



3b



3c

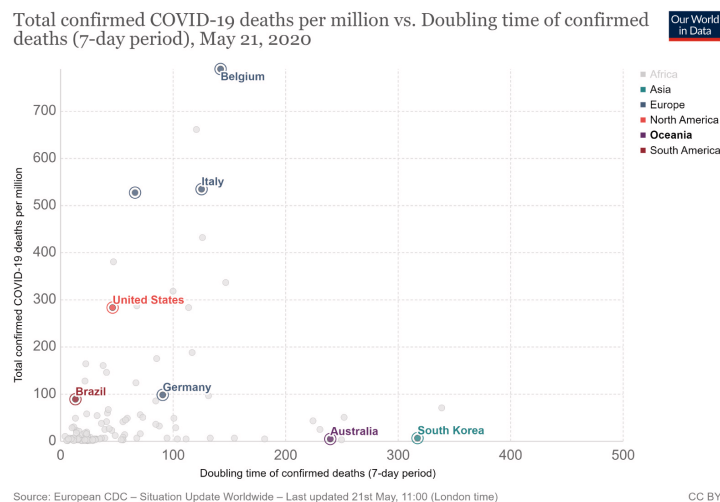
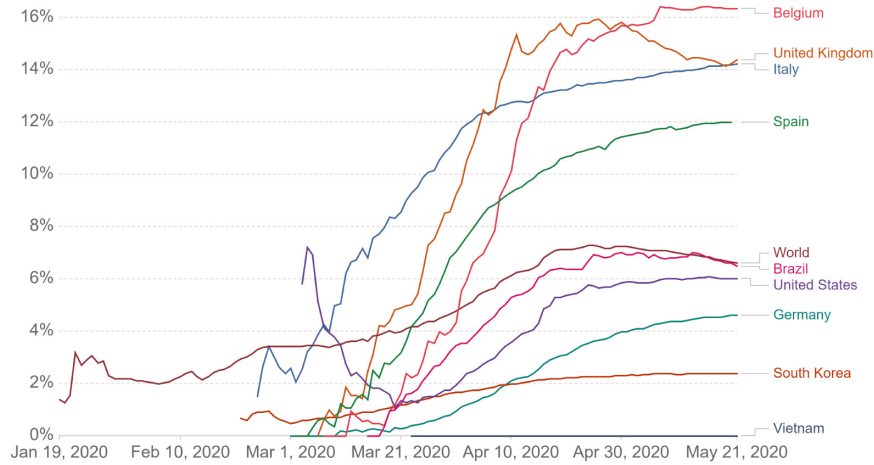


Figure 3. Contain. These graphs show **a**) total confirmed COVID-19 cases per million people **b**) total confirmed COVID-19 cases per million people compared to doubling time of total confirmed cases (7-day period) **c**) total confirmed COVID-19 deaths per million people against time **d**) total confirmed COVID-19 deaths per million compared to doubling time of confirmed deaths (7-day period). Updated graphs can be found [here](#), [here](#), [here](#) and [here](#).

4a

Case fatality rate of the ongoing COVID-19 pandemic

The Case Fatality Rate (CFR) is the ratio between confirmed deaths and confirmed cases. During an outbreak of a pandemic the CFR is a poor measure of the mortality risk of the disease. We explain this in detail at OurWorldInData.org/Coronavirus

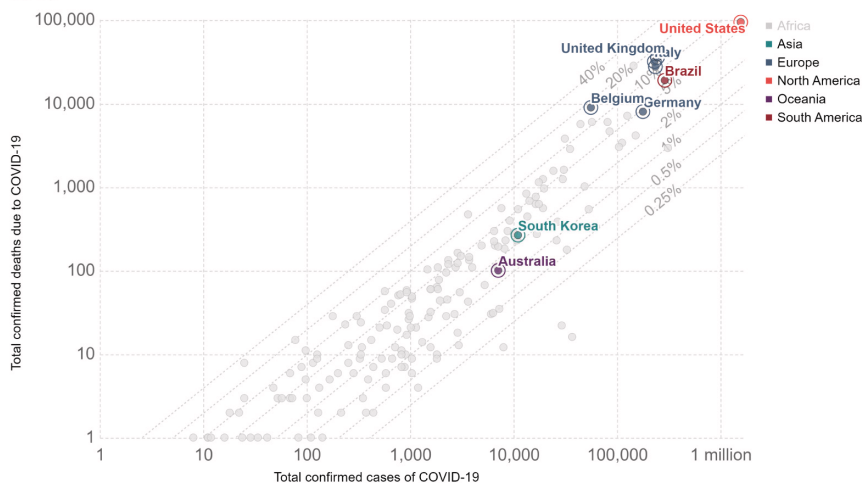


Source: European CDC – Situation Update Worldwide – Last updated 21st May, 11:00 (London time) OurWorldInData.org/coronavirus • CC BY
 Note: Only countries with more than 100 confirmed cases are included.

4b

Total confirmed COVID-19 deaths vs. cases, May 21, 2020

The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing. The grey lines show the corresponding case fatality rates, CFR (the ratio between confirmed deaths and confirmed cases).



Source: European CDC – Situation Update Worldwide – Last updated 21st May, 11:00 (London time) OurWorldInData.org/coronavirus • CC BY

Figure 4. Treat. These graphs show **a)** case fatality rate against time **b)** Total confirmed COVID-19 deaths vs. cases. Updated graphs can be found [here](#) and [here](#).

indicators of success, and differing experiences, from whom lessons could be drawn. In these countries, high levels of testing early in the outbreak and continued increases in capacity with rising cases, appear to have supported containment. Both Vietnam and South Korea have had experience of other recently emerged coronaviruses with probable zoonotic origins¹⁸, Severe acute respiratory syndrome coronavirus (SARS-CoV-1) and Middle East respiratory syndrome (MERS), respectively,

which has likely supported their response to COVID-19¹⁹; both countries rapidly scaled up capacity for testing²⁰.

Although we sought to develop and apply objective indicators in our analysis, we recognize limitations to our process. We may have excluded countries from whom other particular lessons could be drawn. We did not include Australia in the final selection, for example, due to its particular geography. Other

countries were excluded based on population size, for example Iceland and New Zealand. Iceland has very high testing per capita, and New Zealand quickly put in place widespread restrictions, and reported elimination of COVID-19 in May 2020²¹. Many African countries have not been included due to insufficient cases and limited availability of testing data at the time of analysis, who have used low-cost approaches²². Other countries, such as Sweden, have aimed to increase population-level immunity through community-wide infection to avoid a second wave of infection, and the success of this will only be known with time.

We assessed countries as single units, but recognize that there can be variations within a country; countries with large populations may not be comparable to smaller countries where the outbreak does not vary by subnational region. Within the United States, for example, each of the 50 states has different systems in place for testing and reporting. We also could not assess the details of testing strategies. In countries with widespread transmission, targeting testing at key groups such as health care workers or high-risk locations such as hospitals and care homes may be appropriate, but lead to lower apparent testing and/or higher apparent CFR. For countries coming out of widespread restrictions and returning to strategies of intensive testing and contact tracing, there are insufficient data as yet to assess success in avoidance of a “second wave” of infection.

It is also true that countries have very different challenges. Many factors unrelated to interventions affect the spread and impact of COVID-19. For example, there is high transmission in urban centres, where the outbreak will be harder to contain. Population demographics will also influence the case fatality rate (CFR) for COVID-19 which varies by sex, age, and the presence of comorbidities^{23,24}. As well as true variation due to these factors, the variation in CFR between countries is highly subject to testing and reporting¹¹. Belgium, for example, has a comprehensive approach in its counting of deaths with COVID-19 (for example including those in care homes from the outset, where high proportions of deaths have occurred in many contexts) and, of the countries meeting our selection criteria, Belgium reported the highest number of deaths per million (692).

Our assessment was also limited to raw data, without the use of modelling, for example, to provide estimates of the prevalence of COVID-19 and/or infection fatality risks for specific countries. Whilst modelling approaches are important, and considerable work has subsequently been undertaken worldwide²⁵, this was outside the scope of this paper, aiming to identify exemplar countries. In addition, even with modelling, many limitations in different data streams in different countries, remain, as described. In the longer-term, data on excess mortality (exceedance in number of actual deaths compared to expected deaths over a defined time period in a country) will provide comparative data to better assess a country’s success in terms of mitigating the impact of the COVID-19 outbreak²⁶.

It is important to look for countries with emerging success stories now, despite the challenges in doing so. SARS-CoV-2 continues to spread worldwide and policy makers are faced with difficult decisions daily. Here we describe a systematic approach to identifying success, from the range of current metrics available and with consideration of their limitations. We are facing a global challenge. In many countries, it may be only just beginning. Looking for lessons, and sharing them, is critical.

Data availability

Source data

All data are publicly available and shared through Our World In Data and Exemplars in Global Health websites. A summarized version of the results of this work is shared on these websites <https://ourworldindata.org/coronavirus> and <https://www.exemplars.health/emerging-topics/epidemic-preparedness-and-response/covid-19/finding-covid-19-success-stories>.

The underlying data and scripts used to produce all datasets by Our World in Data are made publicly available on GitHub under a [Creative Commons Attribution 4.0 International](https://creativecommons.org/licenses/by/4.0/) (CC BY 4.0) license.

Acknowledgements

We thank Jeremy Derfner, Gates Ventures.

References

- Lu R, Zhao X, Li J, *et al.*: **Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding.** *Lancet.* 2020; **395**(10224): 565–74. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- World Health Organization: **WHO Coronavirus disease (COVID-2019) situation reports 2020.** (accessed 18/05/2020). [Reference Source](#)
- World Health Organisation: **Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV) 2020.** (accessed 18/05/2020). [Reference Source](#)
- Bedford J, Enria D, Giesecke J, *et al.*: **COVID-19: towards controlling of a pandemic.** *Lancet.* 2020; **395**(10229): 1015–8. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Mehtar S, Preiser W, Lakhe NA, *et al.*: **Limiting the spread of COVID-19 in Africa: one size mitigation strategies do not fit all countries.** *The Lancet Global Health.* 2020. [Publisher Full Text](#)
- United Nations Development Programme.** (accessed 18/05/2020). [Reference Source](#)
- Roser M, Ritchie H, Ortiz-Ospina E, *et al.*: **Coronavirus Pandemic (COVID-19).** 2020; (accessed 18/05/2020). [Reference Source](#)
- GHS Index: **2019 Global Health Security Index - GHS Index.** 2019; (accessed

- 18/05/2020).
[Reference Source](#)
9. World Health Organization: **Operational Planning Guidelines To Support Country Preparedness And Response.** 2020; (accessed 18/05/2020).
[Reference Source](#)
 10. The Lancet Respiratory Medicine: **COVID-19: delay, mitigate, and communicate.** *Lancet Respir Med.* 2020; **8**(4): 321.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 11. Onder G, Rezza G, Brusaferro S: **Case-Fatality Rate and Characteristics of Patients Dying in Relation to COVID-19 in Italy.** *JAMA.* 2020; **323**(18): 1775–1776.
[PubMed Abstract](#) | [Publisher Full Text](#)
 12. Linton NM, Kobayashi T, Yang Y, *et al.*: **Incubation Period and Other Epidemiological Characteristics of 2019 Novel Coronavirus Infections with Right Truncation: A Statistical Analysis of Publicly Available Case Data.** *J Clin Med.* 2020; **9**(2): 538.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 13. Baud D, Qi X, Nielsen-Saines K, *et al.*: **Real estimates of mortality following COVID-19 infection.** *Lancet Infect Dis.* 2020; **20**(7): 773.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 14. Docherty AB, Harrison EM, Green CA, *et al.*: **Features of 16,749 hospitalised UK patients with COVID-19 using the ISARIC WHO Clinical Characterisation Protocol.** *medRxiv.* 2020; (accessed 17/05/2020).
[Publisher Full Text](#)
 15. The OpenSAFELY Collaborative, Williamson E, Walker A, *et al.*: **OpenSAFELY: factors associated with COVID-19-related hospital death in the linked electronic health records of 17 million adult NHS patients.** *medRxiv.* 2020; (accessed 17/05/2020).
[Publisher Full Text](#)
 16. Ritchie H, Mathieu E, Rodés-Guirao L, *et al.*: **Mortality Risk of COVID-19.** 2020; (accessed 18/05/2020).
[Reference Source](#)
 17. Pham TQ, Rabaa MA, Duong LH, *et al.*: **The first 100 days of SARS-CoV-2 control in Vietnam.** *medRxiv.* 2020; 2020.05.12.20099242.
[Publisher Full Text](#)
 18. Kock RA, Karesh WB, Veas F, *et al.*: **2019-nCoV in context: lessons learned?** *Lancet Planet Health.* 2020; **4**(3): e87–e88.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 19. Park M, Thwaites RS, Openshaw PJM: **COVID-19: Lessons from SARS and MERS.** *Eur J Immunol.* 2020; **50**(3): 308–11.
[Publisher Full Text](#)
 20. Balilla J: **Assessment of COVID-19 Mass Testing: The Case of South Korea.** 2020; (accessed 18/05/2020).
[Publisher Full Text](#)
 21. Cousins S: **New Zealand eliminates COVID-19.** *Lancet.* 2020; **395**(10235): 1474. (accessed 18/05/2020).
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 22. Boland S: **Covid-19 has forced a reckoning—the UK has much to learn from low income settings.** *BMJ.* 2020; (accessed 14/05/2020).
[Reference Source](#)
 23. Verity R, Okell LC, Dorigatti I, *et al.*: **Estimates of the severity of coronavirus disease 2019: a model-based analysis.** *Lancet Infect Dis.* 2020; **20**(6): 669–677.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 24. Guan WJ, Liang WH, Zhao Y, *et al.*: **Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis.** *Eur Respir J.* 2020; **55**(5): 2000547.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 25. Aguas R, White L, Hupert N, *et al.*: **Modelling the COVID-19 pandemic in context: an international participatory approach.** *BMJ Glob Health.* 2020; **5**(12): e003126.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 26. Aron J, Muellbauer J: **Measuring excess mortality: England is the European outlier in the Covid-19 pandemic.** *CEPR Policy Portal.* 2020; (accessed 21/05/2020).
[Reference Source](#)

Open Peer Review

Current Peer Review Status:  

Version 2

Reviewer Report 13 October 2021

<https://doi.org/10.21956/gatesopenres.14650.r31223>

© 2021 Coelho F. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

 **Flavio Codeco Coelho** 

¹ School of Applied Mathematics, Fundação Getulio Vargas, Rio de Janeiro, Brazil

² Institute of Global Health, University of Geneva, Geneva, Switzerland

I have no further comments.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Infectious disease epidemiology, Mathematical epidemiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 29 September 2021

<https://doi.org/10.21956/gatesopenres.14650.r31222>

© 2021 Kock R. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

 **Richard A. Kock** 

Department of Pathobiology and Population Science, Royal Veterinary College, London, UK

No further comment.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Emerging Infectious Diseases of animal origin

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 17 September 2020

<https://doi.org/10.21956/gatesopenres.14328.r29571>

© 2020 Coelho F. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**Flavio Codeco Coelho** ¹ School of Applied Mathematics, Fundação Getulio Vargas, Rio de Janeiro, Brazil² Institute of Global Health, University of Geneva, Geneva, Switzerland

The idea behind the study is very important: to rank countries by success in fighting their COVID-19 epidemics.

However, the manuscript presents only raw data without any statistical modeling. It is fairly well established that factors such as Age and comorbidities are important in determining the development of symptoms and the risk of hospitalization and death. The authors acknowledge this in the discussion, but the comparison between countries would be fairer if it was based on incidence and mortalities stratified by Age class. Co-morbidities are harder to control for, without having individual case data.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Infectious disease epidemiology, Mathematical epidemiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 27 Sep 2021

Anna Seale, London School of Hygiene & Tropical Medicine/ Public Health England, London, UK

Many thanks for this Review. Whilst we recognize the importance of modelling to support better estimation of disease and/or infection fatality risks, for example, this would be a different undertaking to the work done here, which aimed to identify exemplar countries, rapidly, to support public health policy. However, we have updated the discussion to more clearly reflect this limitation in our work and reflect this important comment.

Competing Interests: No competing interests were disclosed.

Reviewer Report 07 September 2020

<https://doi.org/10.21956/gatesopenres.14328.r29306>

© 2020 Kock R. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



Richard A. Kock 

Department of Pathobiology and Population Science, Royal Veterinary College, London, UK

The article 'COVID-19: Identifying countries with indicators of success in responding to the outbreak' examines different responses to COVID-19 and relative success, looking to explain key factors that might be critical to that success. In order to handle the diversity in demographics population minimums, and case minimums and data availability were used as a filter for analysis. Success was judged on detection rates, containment, and treatment of cases and outcomes. To enable comparison, data was standardised indicators per capita per million and over time. 3 countries were then selected as success stories showing diversity of region, demographic and governance. This is a relatively crude analysis but given the complexities in dealing with data comparabilities, well put together and it also recognises and states the weaknesses and need to re-examine the outcomes in the longer term. Nevertheless this analysis has shown considerable differences between states that might have been considered e.g. on GHSI to have similar strengths in the health systems and likely therefore to show similar outcomes. This was not the case and factors which determined success are not necessarily correlated with governance, relative wealth and capacity. The importance of sustained and consistent policy was also

demonstrated in the initial testing response of the UK (high) and subsequent dropping of this in favour of other actions which was associated with a relatively poor outcome in the end for this country especially with respect to the successful countries highlighted, which used testing as a mainstay from the outset.

There are no errors that I can detect in the data presented but some sentences would benefit with a fresh look to ensure clear expression and explanation. There is one statement which I think needs revision and this is in the conclusion where reference is made of other zoonotic coronaviruses. As no animal source has been confirmed for SARS - 1 or SARS - 2 and given all known cases have been transmitted human to human or from fomites and there is confirmed evidence only for zoonoanthroponosis (reverse zoonosis), it would be more accurate to state the probable zoonotic origins of SARS viruses rather than a zoonosis per se. An alternative more accurate description would be an emerging human pathogen and disease with probable zoonotic origins (the WHO definition of zoonosis is infection directly transmissible from animals to humans with evidence of a permanent animal reservoir.) I recommend this article is indexed with minimal revision required.

Correction to citation 18: R. A. Kock

References

1. Haider N, Yavlinsky A, Chang Y, Hasan M, et al.: The Global Health Security index and Joint External Evaluation score for health preparedness are not correlated with countries' COVID-19 detection response time and mortality outcome. *Epidemiology and Infection*. 2020. 1-18 [Publisher Full Text](#)

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Emerging Infectious Diseases of animal origin

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 27 Sep 2021

Anna Seale, London School of Hygiene & Tropical Medicine/ Public Health England, London, UK

Many thanks for this Review. We have revised the manuscript according to the comments made.

Competing Interests: No competing interests were disclosed.
