



## RESEARCH ARTICLE

**REVISED** **Impact of baseline cases of cough and fever on UK COVID-19 diagnostic testing rates: estimates from the Bug Watch community cohort study [version 2; peer review: 2 approved]**

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**V2** First published: 24 Sep 2020, 5:225  
<https://doi.org/10.12688/wellcomeopenres.16304.1>

Latest published: 25 Jan 2021, 5:225  
<https://doi.org/10.12688/wellcomeopenres.16304.2>

### Abstract

**Background:** Diagnostic testing forms a major part of the UK's response to the current coronavirus disease 2019 (COVID-19) pandemic with tests offered to anyone with a continuous cough, high temperature or anosmia. Testing capacity must be sufficient during the winter respiratory season when levels of cough and fever are high due to non-COVID-19 causes. This study aims to make predictions about the contribution of baseline cough or fever to future testing demand in the UK.

**Methods:** In this analysis of the Bug Watch community cohort study, we estimated the incidence of cough or fever in England in 2018-2019. We then estimated the COVID-19 diagnostic testing rates required in the UK for baseline cough or fever cases for the period July 2020-June 2021. This was explored for different rates of the population requesting tests, four COVID-19 second wave scenarios and high and low baseline cough or fever incidence scenarios.

**Results:** Under the high baseline cough or fever scenario, incidence in the UK is expected to rise rapidly from 250,708 (95%CI 181,095 -

### Open Peer Review

Reviewer Status

|   | Invited Reviewers |            |
|---|-------------------|------------|
|   | 1                 | 2          |
| <b>version 2</b><br>(revision)<br>25 Jan 2021 | <br>report        |            |
|   | ↑                 |            |
| <b>version 1</b><br>24 Sep 2020               | ?<br>report       | <br>report |

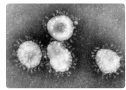
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347,080) cases per day in September to a peak of 444,660 (95%CI 353,084 - 559,988) in December. If 80% of these cases request tests, testing demand would exceed 1.4 million tests per week for five consecutive months. Demand was significantly lower in the low cough or fever incidence scenario, with 129,115 (95%CI 111,596 - 151,679) tests per day in January 2021, compared to 340,921 (95%CI 276,039 - 424,491) tests per day in the higher incidence scenario.

**Conclusions:** Our results show that national COVID-19 testing demand is highly dependent on background cough or fever incidence. This study highlights that the UK's response to the COVID-19 pandemic must ensure that a high proportion of people with symptoms request tests, and that testing capacity is sufficient to meet the high predicted demand.

### Keywords

COVID-19, cough, fever, diagnostic testing capacity, United Kingdom, swab test



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

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

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**Author roles:** **Eyre MT:** Conceptualization, Formal Analysis, Methodology, Software, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Burns R:** Formal Analysis, Methodology, Writing – Original Draft Preparation, Writing – Review & Editing; **Kirkby V:** Writing – Original Draft Preparation, Writing – Review & Editing; **Smith C:** Data Curation, Investigation, Supervision, Writing – Review & Editing; **Denaxas S:** Writing – Review & Editing; **Nguyen V:** Writing – Review & Editing; **Hayward A:** Conceptualization, Funding Acquisition, Writing – Review & Editing; **Shallcross L:** Writing – Review & Editing; **Fragaszy E:** Data Curation, Investigation, Project Administration, Supervision, Writing – Review & Editing; **Aldridge RW:** Conceptualization, Funding Acquisition, Supervision, Writing – Review & Editing

**Competing interests:** No competing interests were disclosed.

**Grant information:** This study was supported by the Wellcome Trust through funding to Health Data Research UK and a Wellcome Trust Clinical Research Career Development Fellowship to RWA [206602]. The work was supported by Health Data Research UK [LOND1], which is funded by the UK Medical Research Council, Engineering and Physical Sciences Research Council, Economic and Social Research Council, Department of Health and Social Care (England), Chief Scientist Office of the Scottish Government Health and Social Care Directorates, Health and Social Care Research and Development Division (Welsh Government), Public Health Agency (Northern Ireland), British Heart Foundation and Wellcome Trust. This work is also supported by the Economic and Social Research Council [ES/P008321/1], as part of the Preserving Antibiotics through Safe Stewardship (PASS) project. MTE is supported by an MRC studentship. SD is supported by an Alan Turing Fellowship.

*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

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**How to cite this article:** Eyre MT, Burns R, Kirkby V *et al.* **Impact of baseline cases of cough and fever on UK COVID-19 diagnostic testing rates: estimates from the Bug Watch community cohort study [version 2; peer review: 2 approved]** Wellcome Open Research 2021, 5:225 <https://doi.org/10.12688/wellcomeopenres.16304.2>

**First published:** 24 Sep 2020, 5:225 <https://doi.org/10.12688/wellcomeopenres.16304.1>

**REVISED Amendments from Version 1**

We have added an additional analysis to explore a low cough or fever incidence scenario (with an additional [Figure 7](#)) and have made edits throughout the manuscript in response to the peer review comments.

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

**Introduction**

In response to the spread of novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the United Kingdom (UK) has implemented large-scale public health measures that aim to reduce transmission and contact rates in the population. Maintaining control through diagnostic testing and self-isolation will increasingly depend upon self-diagnosis based on an individual's symptoms. Current National Health Service (NHS) guidance is that any person in the community who develops at least one symptom of: a new continuous cough, a high temperature, or a loss of, or change in, normal sense of taste or smell (anosmia), should schedule a swab test with NHS services for home delivery or visit a testing site and self-isolate for up to 10 days after onset of symptoms or until a negative test result is received<sup>1-3</sup>. The NHS Test and Trace service aims to trace and notify close recent contacts of anyone who tests positive for coronavirus, instructing them to self-isolate for 14 days.

The importance of COVID-19 testing in the UK's response to the current pandemic is apparent in the five-pillar testing strategy, described by the UK Government in April 2020. The first two pillars use swab-based testing and molecular diagnosis of COVID-19 using real-time PCR<sup>4</sup>. Pillar 1 of the testing strategy relates to the swab testing for health and care workers and those with a clinical need, carried out by Public Health England (PHE) and NHS labs. Pillar 2 concerns swab testing for the wider population including social care and is carried out with commercial partners. The UK Government stated that an important marker for easing control measures and restrictions included having confidence that operational challenges, such as testing capacity, were “*in hand, with supply able to meet future demand*”<sup>5</sup>.

Fever and cough are common symptoms in other acute respiratory viruses<sup>6</sup>. As a result of the non-specific nature of these respiratory symptoms, a large number of individuals meeting the UK's COVID-19 diagnostic testing criteria – and being subsequently tested – will have cough and/or fever caused by a non-COVID-19 infection. It is therefore important to estimate the total number of cases in the population that would meet the diagnostic testing criteria (including both COVID-19 and non-COVID-19 cases) and the proportion of these cases that would seek testing, in order to ensure sufficient diagnostic testing capacity.

Bug Watch was a prospective community cohort study conducted in England in 2018–2019 that collected daily information on symptoms of a range of acute common

infections<sup>7</sup>. Data collected within the study allows us to estimate the community incidence of fever and cough symptoms in England and describe seasonal patterns across a calendar year. Our study has two main objectives: first, to use Bug Watch data to estimate the all-age monthly incidence of cough or fever in England in the period 2018–2019; second, to estimate the UK COVID-19 diagnostic testing demand under current government testing policy for July 2020 – June 2021.

**Methods****Study design, recruitment and data collection**

Bug Watch was an online prospective community cohort study in England. Full details of the study design, recruitment and data collection are described in the protocol<sup>7</sup>. In brief, participants were recruited through an invitation letter sent to adults who participated in the 2013, 2014 and 2015 Health Survey for England (HSE). Parents or guardians were asked to register their children under 16 and complete surveys on their behalf. Any other adults within the same household were invited to register separately. Recruitment was conducted in four waves in March, June, September and November 2018. Data collected consisted of an online consent form and a baseline survey followed by weekly surveys sent by email to be completed by each participant. Each week, participants were asked to prospectively keep track of a wide range of symptoms of infection using a symptom diary. The primary outcomes of interest for this study were cough (defined as either a dry cough or coughing up phlegm) and fever. Each individual was followed up for six months. Only individuals with a 75% completion rate were included in the analysis.

Out of 19,741 adults who were invited to join the study, a total of 873 participants were included in the analysis (782 adults and 91 children that they had registered), providing a total follow-up time of 23,111 person-weeks. Cohort baseline characteristics have been described in more detail<sup>8</sup>, and are included in Extended data, S1<sup>9</sup>. In terms of indicators of potential selection bias, participants were more likely to be older, female, healthier and living in less deprived areas than the general population of England. Age and sex were adjusted for in subsequent statistical analyses, but healthiness and deprivation levels may have skewed measured incidence rates in the cohort towards lower values than the general population.

**Ethics**

Data were collected using [Research Electronic Data Capture \(REDCap\)](#)<sup>17</sup> surveys hosted on the UCL Data Safe Haven, which is certified to the ISO27001 information security standard and conforms to NHS Digital's Information Governance Toolkit. This study was given ethical approval by the UCL Research Ethics Committee (ID 11813/001).

**Statistical analysis**

**Baseline incidence of cough or fever in England.** The first ten days of follow-up after each participant was recruited into the study were excluded to remove prevalent infection syndromes. For participants reporting cough or fever symptoms within these first ten days, follow-up was started on the first day

after this period with no symptoms. Incident cough or fever were defined as i) when a participant reported cough or fever for the first time (one day of symptoms was recorded as a case); or ii) when either symptom was reported after a period of at least 10 days without symptoms. Non-specific symptoms could extend the duration of a cough or fever infection period. Public Health England reported that there were “low to moderate levels of influenza activity” in the 2018–2019 influenza season, which was comparable to the 2017–2018 season and higher than all other seasons since 2010–2011<sup>10</sup>.

Monthly adjusted incidence rates per 100,000-person-week for cough or fever and confidence intervals were calculated for England, weighting to the mid-2019 population structure of England for age, sex and region<sup>11</sup> by post-stratification using a quasi-Poisson regression model (with the R ‘survey’ package version 4.0<sup>12</sup>). Monthly age-specific incidence rates per 100,000-person-week for cough or fever in England were calculated, weighting by sex and region, and are included in *Extended data*, S2<sup>9</sup>.

#### **UK testing demand due to baseline cough and fever cases.**

Monthly all-age adjusted incidence rates of baseline (non-COVID-19) cough or fever were estimated for the UK, weighting to the mid-2019 population structure of the UK for age and sex<sup>11</sup>. These rates were used to estimate the average number of individuals in the UK with an incident case of non-COVID-19 cough or fever each day for each month in the period July 2020 – June 2021.

Predictions for the daily testing demand expected in the UK between July 2020 and June 2021 due to baseline cough or fever cases were made based on our incidence estimates. We assumed that individuals only request a test on the first day that they experience symptoms. We explored a range of scenarios for the proportion of cough or fever cases that request a test (PROPTTEST). Four values were explored: 40%, 60%, 80% and 100%. The predicted impact of baseline cough or fever cases on UK testing capacity was calculated as the difference between UK Pillar 1 and 2 laboratory testing capacity estimates from August 2020 and predicted testing demand between July 2020 and June 2021 based on these scenarios. Capacity estimates used in this analysis were reported by the UK government for the period 6–12th August 2020 as 1,459,418 tests per week for Pillars 1 and 2, and 880,000 tests per week for only Pillar 2<sup>13</sup>.

**Total UK testing demand including symptomatic COVID-19 cases.** Four scenarios (C1–C4) for additional demand due to a second COVID-19 wave in the UK during winter 2020–2021 were explored. A range of average daily incidences for COVID-19 cases for each month between July 2020 and June 2021 were considered to reflect uncertainty about future COVID-19 transmission levels, from the lowest in scenario C1 to the highest incidences in scenario C4. We used an exponentially weighted multiplication factor with minimum values of 0.002, 0.004, 0.006 and 0.008 in August for scenarios C1–C4, respectively, increasing to peak values of 0.05, 0.10, 0.15 and 0.20 in January – March for these four scenarios.

This multiplication factor was then multiplied by the estimated daily incidence of cough or fever in the UK for each month to provide hypothetical daily COVID-19 incidences for each month. An extended description of these methods can be found in *Extended data*, S3<sup>9</sup>. These scenarios were selected to follow a similar epidemic curve shape to predictions reported in the Academy of Medical Sciences’ report “Preparing for a Challenging Winter 2020/21”<sup>14</sup>, with the highest incidences in January and February 2021 and the peak incidence in our worst-case scenario (C4) equal to the peak incidence predicted in the report for a reproductive number  $R_t=1.5$  between September 2020 to July 2021. Based on estimates from the COVID Symptom Study app, 87.5% of these cases of COVID-19 were assumed to exhibit symptoms of cough, fever or loss of smell or taste<sup>15</sup> with the proportion of these symptomatic cases expected to request tests explored using the PROPTTEST parameter. Total demand for swab tests due to baseline cough and fever cases and COVID-19 illnesses was calculated as:

$$\text{Total demand} = (\text{baseline cough or fever incidence} + \text{COVID19 incidence} \times 0.875) \times \text{PROPTTEST}$$

The total predicted testing demand in each month was then calculated for each COVID-19 scenario (C1–C4).

#### **Total UK testing demand in a low cough or fever incidence scenario.**

Estimated total UK testing demand was adjusted to explore the impact of a reduced incidence of baseline cough or fever cases relative to previous years due to social distancing and other COVID-19 public health interventions. Estimates of the relative reduction in monthly baseline cough or fever incidence for July – November 2020 compared to the corresponding months in the 2018–2019 Bug Watch cohort were available from the preliminary results of the ongoing Virus Watch cohort study (see [www.ucl-virus-watch.net](http://www.ucl-virus-watch.net) for more information about the study) in England (unpublished report, author: Robert Aldridge). These found that the median reduction in non-COVID-19 cough or fever incidence in these months relative to the Bug Watch baseline was 73% (range 34% – 81%). This was used to recalculate estimates of the total UK testing demand for each month assuming a 73% lower incidence of cough or fever relative to our historical baseline for each month.

All analyses were conducted using R version 3.6.3<sup>16</sup> using the R ‘tidyverse’ packages version 1.3.0<sup>17</sup>.

## **Results**

### **Cough or fever incidence in England**

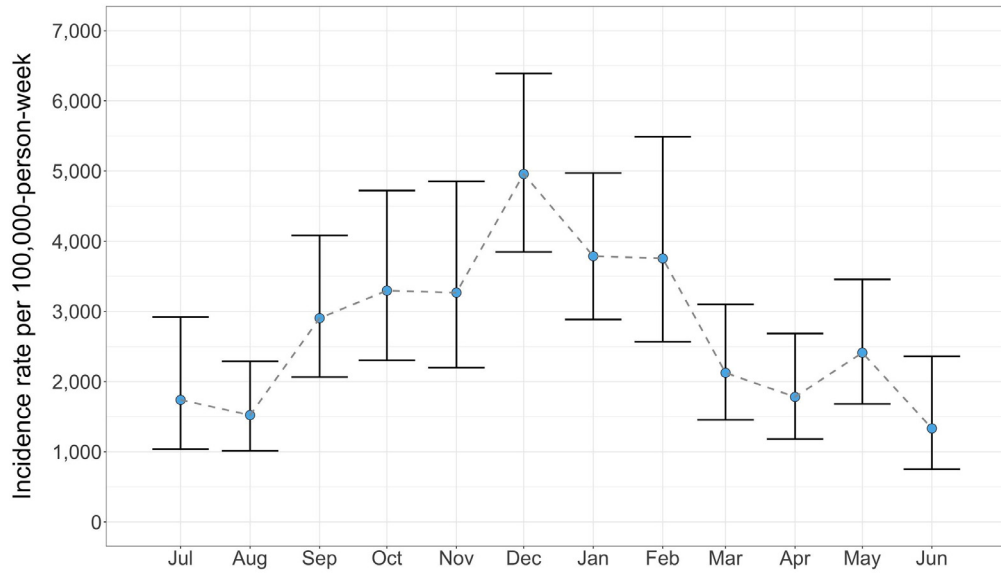
Out of a total of 585 episodes of cough or fever, participants experienced 431 (73.7%; 431/585) episodes of cough, 57 (9.7%; 57/585) of fever and 97 (16.6%; 97/585) episodes with both cough and fever symptoms.

Monthly age-, sex- and region-adjusted incidence rates of cough or fever per 100,000-person-week and 95% confidence intervals are shown for the 12-month study period in England in [Figure 1](#). There was clear seasonal variation in incidence, with the lowest rates in June and highest rates in

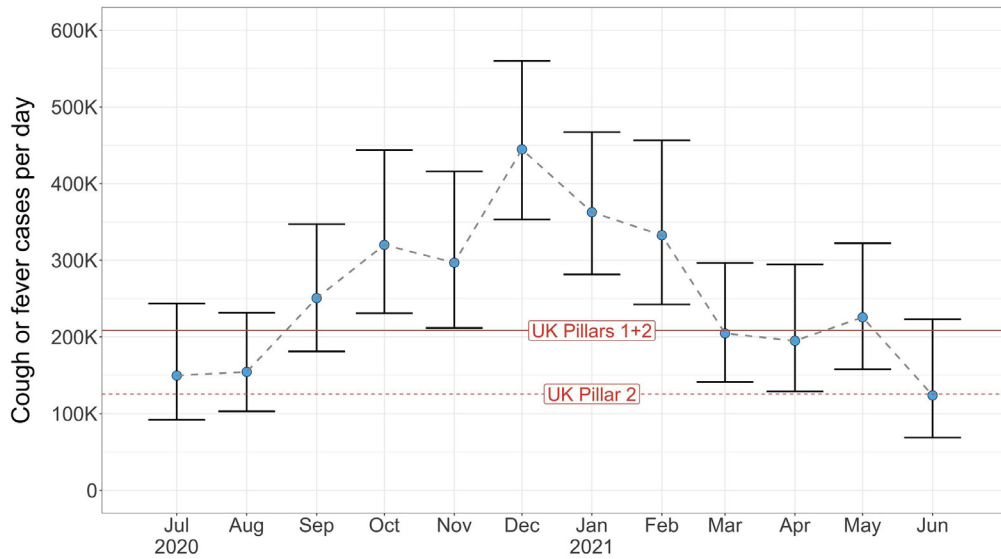
December with 1,333 (95%CI 753 – 2,361) and 4,958 (95%CI 3,847 – 6,390) incident episodes of cough or fever per 100,000-person-week, respectively. The high incidence in December coincides with UK public holidays and lower temperatures, when indoor contact rates are higher.

**UK testing demand due to baseline cough and fever cases**

Predictions for the average daily number of baseline (non-COVID-19) cough or fever cases in the UK between July 2020 – June 2021 are shown for each month in Figure 2. Under



**Figure 1. Monthly adjusted incidence rates of cough or fever per 100,000-person-week in England with 95% confidence intervals.** Weighted to the mid-2019 population structure of England by age, sex and region.



**Figure 2. Predicted baseline number of individuals (in thousands) in the UK with an incident case of cough or fever each day shown for each month.** Laboratory capacity (measured as daily tests) estimates from August 2020 for Pillars 1 and 2 and Pillar 2 in the UK are shown as solid and dashed red lines, respectively.

current UK government policy, all of these cases would be entitled to a COVID-19 swab test. After the lower incidence summer period of 2020, the incidence starts to rise rapidly, increasing from 154,554 (95%CI 103,083 – 231,725) cases per day in August to 250,708 (95%CI 181,095 – 347,080) in September, before peaking at 444,660 (95%CI 353,084 – 559,988) daily cases in December. This high incidence continues to exceed UK laboratory testing capacity in August 2020 for Pillars 1 and 2 until the end of winter before falling to 204,750 (95%CI 141,392 – 296,499) cases per day in March 2021.

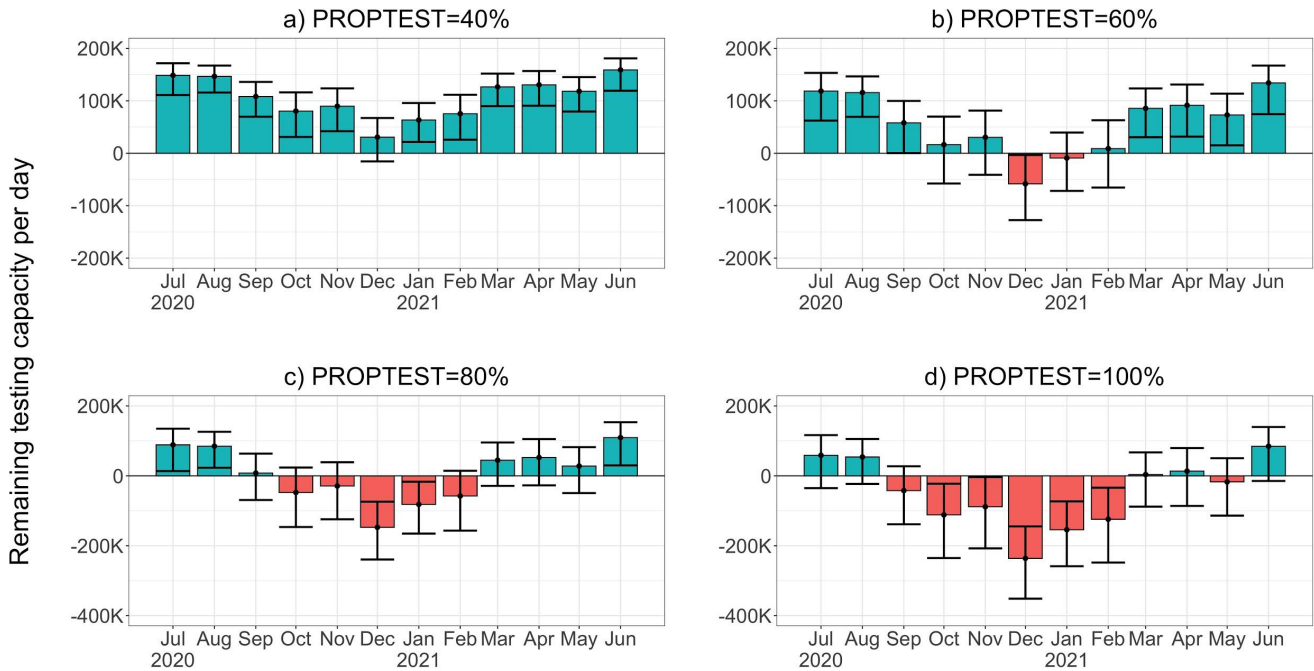
Remaining UK Pillar 1 and 2 capacity after testing baseline cough or fever cases is shown in Figure 3 for four values of the proportion of cough or fever cases which request tests (PROPTEST). The peak in cases in the autumn and winter of 2020–2021 is likely to place significant stress on the UK’s testing service in these months. Figure 3a shows that when only 40% of these cases request tests, capacity is sufficient for the entire year. However, as this proportion increases, capacity becomes insufficient for predicted demand. When 60% request tests, demand in December 2020 and January 2021 exceeds capacity by 58,308 (95%CI 3,362 – 127,505) and 9,121 (95%CI -39,541 – 71,798) tests per day (Figure 3b). For 80% (Figure 3c), the daily average demand for tests exceeds capacity in five consecutive months (October 2020 to February 2021), with a peak of 147,240 (95%CI 73,978 – 239,502) tests per day above capacity expected in December 2020. If all individuals experiencing non-COVID-19 cough or fever request a test, we

estimate that there will only be a significant capacity surplus in the summer months of July and August 2020 and June 2021.

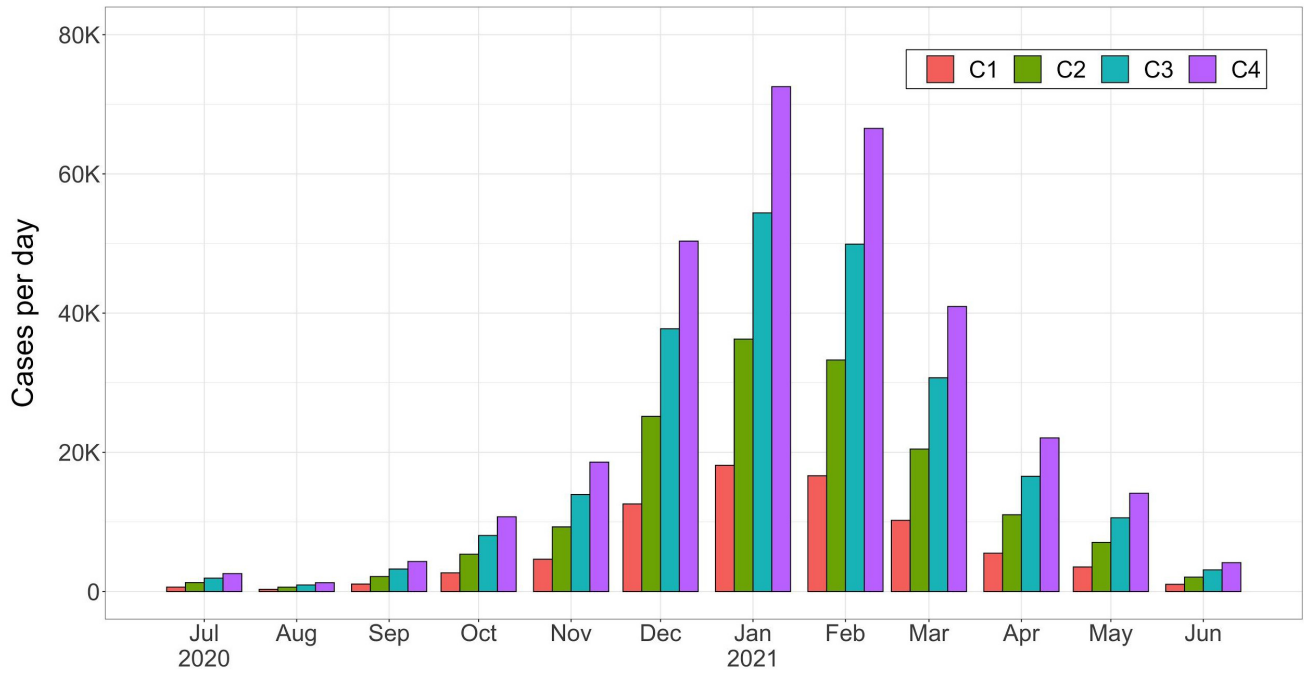
**Total UK testing demand including symptomatic COVID-19 cases**

The four scenarios (C1-C4) for a winter COVID-19 epidemic in the UK which were explored in this study are shown in Figure 4. All scenarios follow the same epidemic curve shape with the highest average daily incidences between December 2020 and March 2021 and peak incidences in January of 18,134 (in scenario C1), 36,268 (C2), 54,402 (C3) and 72,536 (C4) cases per day.

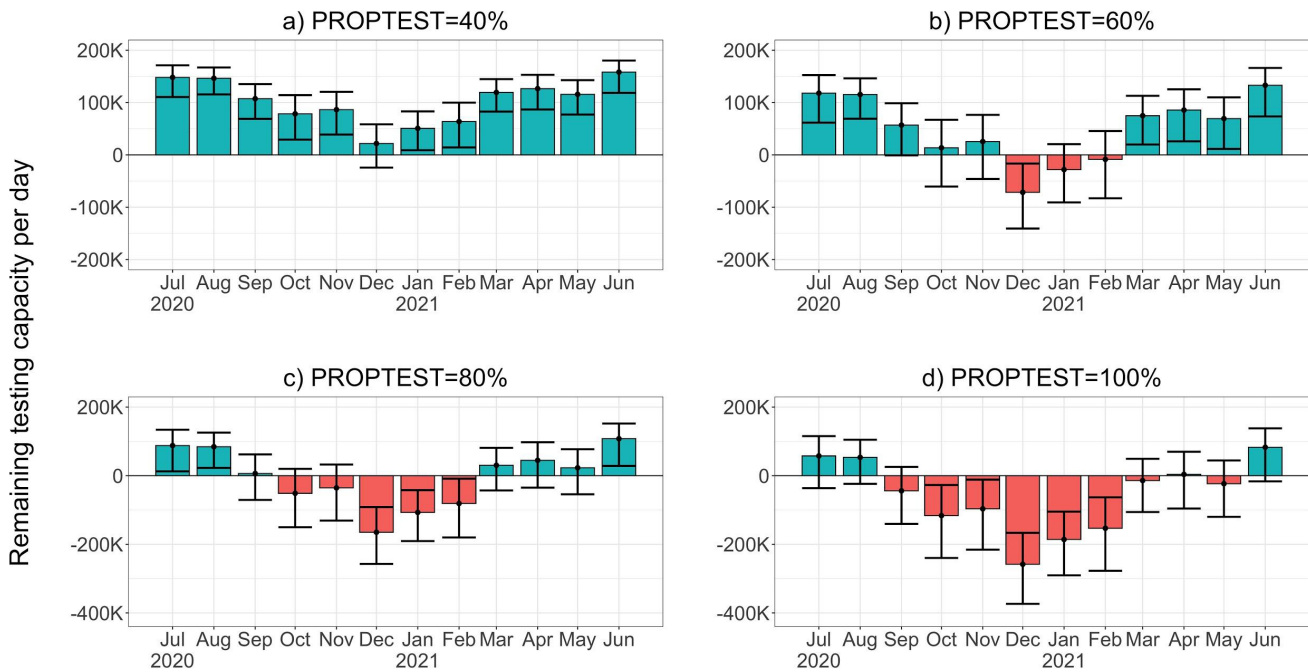
For the midrange C2 scenario, the remaining testing capacity available after testing baseline cough or fever cases and symptomatic COVID-19 cases is shown in Figure 5 (results for all other scenarios were similar and are included in *Extended data*, S4<sup>9</sup>). These results were similar to those for baseline cough or fever cases only (Figure 3). Capacity is not predicted to be exceeded when only 40% of cough or fever cases and symptomatic COVID-19 cases request tests. When 60% of cases request tests, there is a predicted daily demand in December 2020 of 71,522 (95%CI 16,576 – 140,719) tests above capacity and the additional COVID-19 demand pushes total demand in February 2021 above capacity. When 80% of cases request tests, we see an increased deficit during the epidemic’s peak months of December to January and, when 100% request a test, UK testing capacity is predicted to be severely strained from September 2020 to May 2021.



**Figure 3. Remaining UK Pillar 1 and 2 testing capacity (thousands of tests) available after testing baseline (non-COVID-19) cases of cough or fever in the UK each day.** Panels a) to d) show results for four values of the proportion of cough or fever cases requesting tests (PROPTEST). Blue and red bars indicate that cough or fever testing demand is within or in excess of capacity available in August 2020, respectively.



**Figure 4.** Four scenarios (C1 to C4) for average daily COVID-19 incidence in the UK shown for each month.



**Figure 5.** Remaining UK Pillar 1 and 2 testing capacity (thousands of tests) per day after testing baseline (non-COVID-19) cases of cough or fever and symptomatic COVID-19 cases in the UK each day for scenario C2. Panels a) to d) show results for four values of the proportion of cases requesting tests (PROPTEST). Blue and red bars indicate that testing demand is within or in excess of capacity in August 2020, respectively. Note that panel a) has a different y-axis scale to panels b) – d).

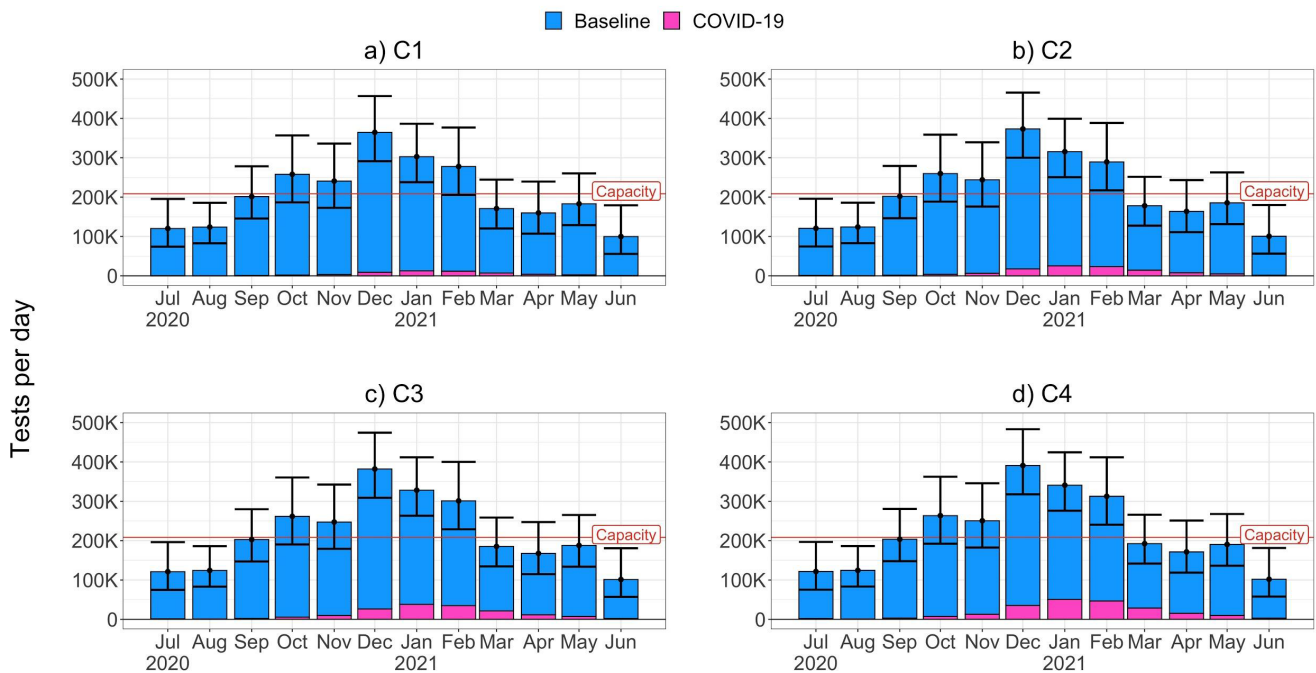
The relatively small contribution of symptomatic COVID-19 cases to total predicted testing demand in the UK for scenario C2 was also found for all other COVID-19 transmission scenarios, shown in Figure 6, for an assumed value of 80% of cases requesting a test. The more severe C3 and C4 scenarios result in higher total demand in January 2021 of 328,227 (95%CI 263,345 – 411,797) and 340,921 (95%CI 276,039 – 424,491) tests per day, respectively, compared to 302,839 (95%CI 237,957 – 386,409) in the C1 scenario. While these increases are not negligible, the total testing demand is predominantly driven by baseline cough or fever cases, and the overall effect of increased COVID-19 transmission between these scenarios is small. For example, in the highest transmission scenario, C4, and peak COVID-19 incidence in January 2021, only 14.9% of tests are expected to be requested by COVID-19 cases. This is a result of the high incidence of baseline cough or fever cases during the second wave peak months of December 2020 to February 2021. Consequently, relative to UK testing capacity in August 2020, the overall picture remains the same across the next year for all four scenarios, with the period October to February at high risk of surpassing UK testing capacity. As the proportion of cases requesting tests is applied to both baseline and symptomatic COVID-19 cases, symptomatic COVID-19 cases contribute the same proportion of the total testing demand for all other values of the proportions of cases requesting tests, although total demand varies significantly with this proportion (see *Extended data, S5<sup>9</sup>*).

### Total UK testing demand in a low baseline cough or fever incidence scenario

The low baseline cough or fever incidence scenario which explored the effect of a 73% reduction in cough or fever incidence relative to the historical baseline is shown in Figure 7. For a C4 transmission scenario with 80% of cases requesting tests, the estimated total UK testing demand was below capacity reaching 129,115 (95%CI 111,596 - 151,679) tests per day in January 2021. This lower cough or fever incidence scenario results in significantly lower levels of total testing demand when compared to the high scenario estimates (Figure 6) which were based on the historical baseline cough or fever incidence. These lower estimated incidences of cough or fever would result in COVID-19 cases playing a more significant role in driving testing demand, with COVID-19 cases constituting 26%, 39%, and 39% of tests requested in December, January and February, respectively.

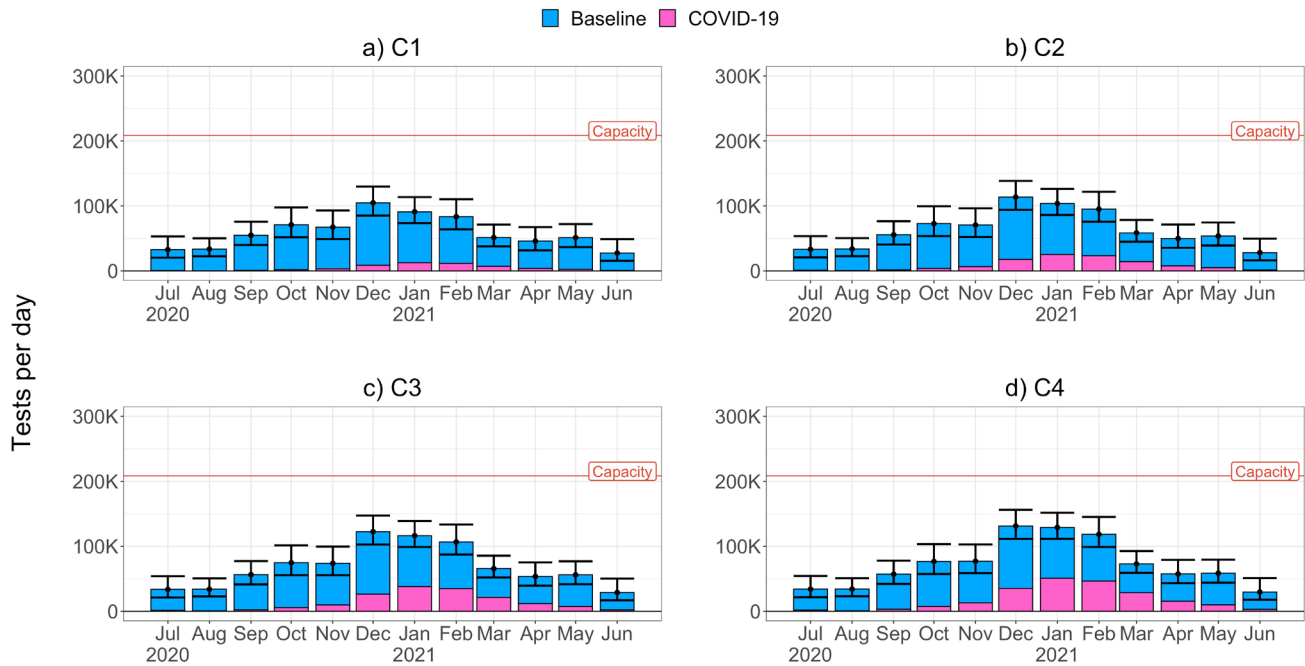
### Discussion

In this study, we estimate the baseline incidence of cough or fever cases and their potential impact on COVID-19 diagnostic testing services in the UK in July 2020 – June 2021. Our results show that if the baseline incidence of cough and fever between September 2020 and February 2021 is similar to incidences in previous years, it may place a significant strain on UK testing capacity. Under these conditions we estimate that if more than 80% of people with symptoms request a test,



**Figure 6.** Predicted daily testing demand (thousands of tests) due to baseline cough or fever cases (blue) and symptomatic COVID-19 cases (pink) in the UK, assuming that 80% of cases request tests. Panels a) to d) show results for scenarios C1 to C4. Daily UK Pillar 1 and 2 testing capacity estimates from August 2020 are marked with a red line.





**Figure 7. Predicted daily testing demand (thousands of tests) due to baseline cough or fever cases (blue) and symptomatic COVID-19 cases (pink) in a low baseline cough or fever incidence scenario (73% lower than 2018–2019 incidence) in the UK, assuming that 80% of cases request tests.**

daily demand for COVID-19 swab tests will exceed the testing capacity available in August 2020 by a significant margin for five months. However, if the baseline incidence of cough or fever consistently remains at significantly lower levels than in previous years then capacity is likely to be sufficient. We find that testing demand in both baseline incidence scenarios will be predominantly driven by baseline cough or fever incidence, rather than symptomatic COVID-19 cases, and that the proportion of people with symptoms who request a test is a key determinant of demand. To our knowledge, this is the first paper published quantifying baseline cough or fever cases in the UK and their impact on COVID-19 diagnostic testing services.

The strong seasonal trend in baseline incidence of cough or fever cases in the UK is a clear indicator of the challenges which the UK's testing services will face in the autumn and winter months of 2020–2021. Our results show that while the UK's diagnostic testing capacity in August 2020 may be sufficient for July to September 2020, this may not be the case during the winter period. If capacity is exceeded to the extent predicted in our results, a large backlog of unprocessed tests can be anticipated and a significant proportion of COVID-19 positive cases are likely to remain untested. Prompt identification of cases is critical for effective contact tracing and real-time visualisation of epidemiological trends to inform national and local-level public health interventions. It is therefore imperative that the UK's testing capacity continues to be scaled up to ensure that there is sufficient capacity to respond to this

predicted rise in testing demand and ensure that the detection of COVID-19 cases is not compromised. Delays in testing, due to lack of capacity, will negatively affect the performance of the track and trace system, may also disincentivise people from getting tested and may result in unnecessarily extended self-isolation of COVID-19 negative households. The UK testing strategy has acknowledged the need to expand testing capacity rapidly<sup>18</sup> and appears to be on track to reach a PCR testing capacity of half a million tests per day by the end of 2020<sup>19</sup>. Our calculations show that if this additional capacity is achieved, it would significantly reduce the risk of testing backlogs over the winter period. However, under high levels of COVID-19 transmission and a baseline incidence of cough or fever which approaches historical levels, it is unlikely to be sufficient to also cover routine testing of asymptomatic health and care professionals<sup>20</sup>. Clearly, any improvements in the UK's testing system must also be matched by the creation of an effective contact tracing system for identifying clusters at the local level and preventing onwards transmission, and by providing support to people to self-isolate – testing alone will not control transmission in the UK.

Our results show that testing demand is likely to be driven by the proportion of people with symptoms that request a test. An effective public health response to COVID-19 in the UK requires all individuals experiencing symptoms to request a test promptly after symptoms begin and our estimates for higher values of the proportion requesting tests should be considered as a necessary requirement for the UK's testing capacity.

Therefore, in addition to scaling up capacity, the UK's response must also ensure that a high proportion of symptomatic people are requesting tests to begin with. Estimates for this proportion are not widely documented, but one recent study found that "that only about 40% of those who report classic COVID-19 symptoms go on to receive a test"<sup>21</sup>. This low value is concerning for COVID-19 control and would suggest that the results in our study for scenarios with lower values of the proportion of cough or fever cases that request a test may be more accurate, and consequently that demand for testing would lie within capacity. However, understanding this test-seeking behaviour is clearly important and should be studied further through future weekly follow-up community studies structured similarly to the Bug Watch study. The potentially high baseline incidence of cough or fever cases reported in our analysis highlights the scale of this issue, and culturally and linguistically appropriate public engagement campaigns, as well as accessible and rapid test-ordering systems, will be critical to a successful response.

In this study, we explore a scenario in which the baseline incidence of cough or fever during the study period of 2018–19 is representative of 2020–2021 and a second scenario in which the incidence during 2020–2021 is 73% lower. Which of these scenarios is most representative of demand in the winter 2020–2021 is likely to depend on the type of public health restrictions which are implemented and how well they are observed by the UK population. The implementation of public health interventions in the UK during autumn 2020 varied geographically with an easing of restrictions in most of the UK during July–September 2020 followed by further restrictions in some higher transmission areas in November and December 2020. Many measures, such as social distancing and bans on mass gatherings, will continue regardless of local restrictions. These public health interventions and changes in behaviour have been impacting upon the incidence of other respiratory pathogens globally, with reduced influenza activity reported in the United States, Australia, Chile and South Africa between June–August 2020<sup>22</sup> and UK surveillance data from 2019 to 2020 suggesting low levels of influenza activity in the community<sup>23</sup>. This is consistent with the preliminary results from the Virus Watch cohort study which were used in the low incidence scenario. The lowest reduction of 34% was in September 2020 which may be explained by the fact that children and young adults can drive transmission of influenza and other seasonal respiratory infections. The reopening of schools and universities in the UK in September 2020 may therefore have maintained baseline cough or fever incidence in this month closer to 2018–19 levels. It is consequently likely that the future incidence of baseline cough or fever cases with an infectious aetiology will depend on the extent to which schools and universities are kept open. Our analysis provides estimates of predicted total testing demand for the reasonable best and worst case of baseline cough and fever incidence and clearly shows that the strain on testing capacity is highly dependent on the extent to which these other respiratory pathogens continue to be transmitted.

The COVID-19 transmission scenarios explored in this study are speculative and reflect uncertainty about the potential size and timing of a second COVID-19 wave. However, they present a range of reasonable scenarios based on previous modelling predictions<sup>14</sup> that are consistent with the expectation that a second wave will have a lower peak incidence and flatter epidemic curve than the first wave in March – July 2020 in the UK<sup>24</sup>. Our results show that total testing demand is relatively insensitive to COVID-19 transmission and that, even in more severe scenarios, testing demand due to baseline cough or fever cases will outweigh demand due to symptomatic COVID-19 cases.

A limitation of our study was that participants were more likely to be older, female, healthier and living in less deprived areas than the general population of England. To account for age and sex, we adjusted for these variables in our incidence estimates. There were also a disproportionately high number of white participants included in the study – meaning that ethnic minority communities that are known to have been particularly adversely affected by COVID-19 were underrepresented<sup>25</sup>. Consequently, our results do not account for possible differences in the incidence of baseline cough and fever in these groups. Another possible limitation of this study is that a cough was defined as 'incident' rather than 'continuous' (lasting more than one hour or three or more coughing episodes in 24 hours), therefore potentially differing from the UK's COVID-19 diagnostic symptomatology. We may consequently overestimate the number of cough cases who would require a test under current NHS guidance. We also note that our estimates of testing demand were largely driven by cough symptoms, as fever was comparatively less common. Data was not collected on altered or lost sense of smell or taste, but we expect this to be rare in comparison to symptoms of cough or fever.

In conclusion, our study provides estimates of the baseline incidence of cough or fever in the general population in the UK. Our estimates indicate that, if baseline cough or fever incidence is maintained at 2018–2019 levels, the UK's COVID-19 testing capacity in August 2020 is insufficient for high predicted demand in winter 2020–2021. However, if cough or fever incidence is maintained at the lower levels observed in October and November 2020 then it is likely to be sufficient, even in the most severe COVID-19 transmission scenario explored in this analysis. This study highlights the need to ensure that a high proportion of people with symptoms request tests and that sufficient testing capacity must be available for testing baseline cough or fever cases. Otherwise, compounded by high COVID-19 levels projected in a second wave, UK testing capacity could be overwhelmed leading to failure of the NHS Test and Trace service and an inability to control the further spread of COVID-19.

#### Patient and public involvement

Participants were not directly involved in design of this study although feedback was collected at two time points during

follow-up. Please see the Bug Watch community cohort study protocol for more information<sup>7</sup>.

## Data availability

### Underlying data

Open Science Framework: Impact of baseline cases of cough and fever on UK COVID-19 diagnostic testing rates: estimates from the Bug Watch community cohort study - Supplementary material, code and data. <https://doi.org/10.17605/OSF.IO/5J6DY><sup>9</sup>

The repository contains the following underlying data:

- data1\_surv\_com\_week.csv (Survey completion rates)
- data2\_bl\_exp.csv (Anonymised individual characteristics of participants)
- data3\_daily.csv (Daily symptom reports)
- ONS\_England\_mid-2019\_extracted\_sex-reg-age.csv (Demographic data extracted from ONS mid-2019 estimates for England, Source: Office for National Statistics licensed under the Open Government Licence v.3.0)
- ONS\_UK\_mid-2019\_extracted\_sex-age.csv (Demographic data extracted from ONS mid-2019 estimates for the United Kingdom, Source: Office for National Statistics licensed under the Open Government Licence v.3.0)
- Virus\_watch\_results\_adj\_month\_2020-12-22.csv (Virus Watch cohort study estimates for the incidence of cough or fever cases in 2020).
- VW\_monthly\_cough\_prop.csv (Estimates of the proportion of cough or fever cases which are not COVID-19 cases from Virus Watch cohort study).

## Extended data

Open Science Framework: Impact of baseline cases of cough and fever on UK COVID-19 diagnostic testing rates: estimates from the Bug Watch community cohort study - Supplementary material, code and data. <https://doi.org/10.17605/OSF.IO/5J6DY><sup>9</sup>

This repository contains the R script used to conduct this analysis, supplementary material, underlying data and STROBE cohort study reporting checklist.

This project contains the following extended data:

- S1. Study population information
- S2. Age-specific incidence rates of cough or fever
- S3. COVID-19 incidences for scenarios C1 to C4
- S4. Full exploration of proportion requesting test values for each scenario: C1, C3 and C4
- S5. Full exploration of scenarios C1, C3 and C4 for each proportion requesting test value: 40%, 60%, 100%
- S6. Estimated cough incidence rates in England
- S7. Estimated fever incidence in England

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

## Acknowledgements

The authors are extremely grateful to all the participants who took part in the Bug Watch community cohort study.

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# Open Peer Review

Current Peer Review Status:  

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## Version 2

Reviewer Report 17 February 2021

<https://doi.org/10.21956/wellcomeopenres.18263.r42288>

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**Cheryl Cohen** 

Centre for Respiratory Diseases and Meningitis, National Institute for Communicable Diseases of the National Health Laboratory Service, Johannesburg, South Africa

I have reviewed the authors responses and I am happy with them.

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Infectious disease epidemiology, viral respiratory illness.

**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.**

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## Version 1

Reviewer Report 19 October 2020

<https://doi.org/10.21956/wellcomeopenres.17916.r40603>

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**Angela Raffle**

Consultant in Public Health, The NHS Screening Programmes, University of Bristol Medical School Population Health Sciences, Bristol, UK

This article is well summarised in the abstract, and in the text provided by Reviewer 1.

**General comment:**

- This is a clear and well-written paper that addresses an important issue. I agree with the points made by Reviewer 1.

**Specific comments:**

## Abstract:

- If possible within the word count, it would be good to include that the pillars 1 plus 2 capacity estimate being used is 1.4 million tests/week.

## Introduction:

- 'The NHS Test and Trace service will trace and notify close recent contacts of anyone who tests positive for coronavirus to self-isolate for 14 days.' It would be more correct to say that they 'aim to' rather than they 'will'. Also, adding the words 'instructing them' to self-isolate would be less cryptic.
- Last paragraph, would it not be more correct to say 'Bug Watch allows us to estimate' (rather than quantify), as said later. The sample was 873 participants, with potential for selection bias, so extrapolating to the entire population and to different years gives only an estimate.

## Methods:

- There should be mention in the methods or results sections of whether, and potentially how, selection bias may have skewed the measured incidence rates in Big Watch. This is touched on in the discussion, but it would be better to state it earlier in the paper.
- Baseline incidence of cough or fever in England - I found this paragraph hard to follow. I could not quite grasp how the term 'follow-up' was being used. Is this about excluding days from the denominator?
- Also, was cough or fever defined as any mention of these symptoms i.e. one day of reporting only? This needs to be specified in the methods section because this could be quite a 'low bar' for defining cough or fever. There is mention in the discussion, but I found it a bit ambiguous – was the 'continuous' cough definition used? This needs to be clear in the methods section.
- Also, mention of whether 2018/19 a high, low, or medium year for respiratory illnesses in general, would be helpful.
- Is it possible to use general practice morbidity data to add further insight into the relationship between the incidence of new cough or fever from the Bug Watch study, compared with GP consultation rates? This could give some insight into whether the 40, 60, or 80 percent seeking testing is most likely to be accurate. This is not an essential change, but would be a 'nice to have'.
- Covid 19 estimates – I am not qualified to comment on the validity of these estimates

## Discussion:

- At one point the term ‘antigen’ testing is used – does this mean PCR testing for viral RNA? It is potentially confusing to refer to this as antigen testing.
- The discussion only considers the need for greater testing capacity. It would be worth also mentioning the need to use tests to best effect. For example, as data develops on the predictive value of certain symptoms for ruling in and ruling out SARS-CoV-2 there may be scope for refining who should be offered a test e.g. cough with phlegm was presumably included in Bug Watch but is a dry cough more indicative of SARS-CoV-2? Also the timing of the test matters – if there is a delay in seeking a test then the result would not shorten the isolation period and it is too late to effectively act on all the contacts etc. Also, there has been considerable criticism of Test and Trace, so perhaps a phrase emphasising that a test alone is pointless. Testing must form part of a well-coordinated system that reliably leads to effective contact tracing, to prompt local action for dealing with clusters, and to support for those who are needing to self-isolate.

**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?**

Partly

**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:** Public Health Screening Programmes, NHS Public Health service provision including general (non-specialist) communicable disease control.

**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 15 Jan 2021

**Max Eure**, Lancaster University, Lancaster, UK

Many thanks for the time you have spent reviewing our paper and your very helpful and constructive comments on the paper. We have tried to address all of the points you have

raised and to update the paper as much as is reasonably possible within the rapidly changing context. There is now an additional analysis which explores a lower (73% lower) cough or fever incidence scenario based on preliminary estimates from the Virus Watch cohort study we are running at UCL. We provide numbered point by point responses to your comments below.

**Reviewer comment 1:**

Abstract - If possible within the word count, it would be good to include that the pillars 1 plus 2 capacity estimate being used is 1.4 million tests/week.

**Author response 1:**

This has been added. We have also made clear that this was the capacity in August 2020.

**Reviewer comment 2:**

Introduction - 'The NHS Test and Trace service will trace and notify close recent contacts of anyone who tests positive for coronavirus to self-isolate for 14 days.' It would be more correct to say that they 'aim to' rather than they 'will'. Also, adding the words 'instructing them' to self-isolate would be less cryptic. Last paragraph, would it not be more correct to say 'Bug Watch allows us to estimate' (rather than quantify), as said later. The sample was 873 participants, with potential for selection bias, so extrapolating to the entire population and to different years gives only an estimate.

**Author response 2:**

Thank you for these suggestions, we have added both of these corrections into the introduction.

**Reviewer comment 3:**

Methods - There should be mention in the methods or results sections of whether, and potentially how, selection bias may have skewed the measured incidence rates in Big Watch. This is touched on in the discussion, but it would be better to state it earlier in the paper.

**Author response 3:**

Thank you for this comment, we have highlighted the potential for selection bias and commented on its potential skew in the methods section.

**Reviewer comment 4:**

Methods - Baseline incidence of cough or fever in England - I found this paragraph hard to follow. I could not quite grasp how the term 'follow-up' was being used. Is this about excluding days from the denominator?

**Author response 4:**

It should hopefully be clearer now that we excluded the first ten days for all participants after they entered the study - "The first ten days of follow-up after each participant was recruited into the study were excluded to remove prevalent infection syndromes."

**Reviewer comment 5:**

Methods - Also, was cough or fever defined as any mention of these symptoms i.e. one day



of reporting only? This needs to be specified in the methods section because this could be quite a 'low bar' for defining cough or fever. There is mention in the discussion, but I found it a bit ambiguous – was the 'continuous' cough definition used? This needs to be clear in the methods section.

**Author response 5:**

Thank you for pointing this out - we have clarified that a single day of reporting the symptom counts as a case of cough or fever. The symptom definition used for cough is described in the first paragraph of the methods section.

**Reviewer comment 6:**

Methods - Also, mention of whether 2018/19 a high, low, or medium year for respiratory illnesses in general, would be helpful.

**Author response 6:**

Thank you for this helpful suggestion. Please see the sentence we have added in the methods section: "Public Health England reported that there were "low to moderate levels of influenza activity" in the 2018-2019 influenza season, which was comparable to the 2017-2018 season and higher than all other seasons since 2010-2011".

**Reviewer comment 7:**

Methods - Is it possible to use general practice morbidity data to add further insight into the relationship between the incidence of new cough or fever from the Bug Watch study, compared with GP consultation rates? This could give some insight into whether the 40, 60, or 80 percent seeking testing is most likely to be accurate. This is not an essential change, but would be a 'nice to have'.

**Author response 7:**

We have added a new reference in the discussion section which estimates "that only about 40% of those who report classic COVID-19 symptoms go on to receive a test". We then comment on the implications of this on COVID-19 control and our results, and stress the importance of future studies looking at test-seeking behaviour and comment on how they can be structured.

**Reviewer comment 8:**

Discussion - At one point the term 'antigen' testing is used – does this mean PCR testing for viral RNA? It is potentially confusing to refer to this as antigen testing.

**Author response 8:**

This has been corrected.

**Reviewer comment 9:**

Discussion - The discussion only considers the need for greater testing capacity. It would be worth also mentioning the need to use tests to best effect. For example, as data develops on the predictive value of certain symptoms for ruling in and ruling out SARS-CoV-2 there may be scope for refining who should be offered a test e.g. cough with phlegm was presumably included in Bug Watch but is a dry cough more indicative of SARS-CoV-2? Also

the timing of the test matters – if there is a delay in seeking a test then the result would not shorten the isolation period and it is too late to effectively act on all the contacts etc. Also, there has been considerable criticism of Test and Trace, so perhaps a phrase emphasising that a test alone is pointless. Testing must form part of a well-coordinated system that reliably leads to effective contact tracing, to prompt local action for dealing with clusters, and to support for those who are needing to self-isolate.

**Author response 9:**

We have addressed this important point by inserting some additional text in the discussion which highlights that testing is only useful when accompanied by an effective contact tracing and a system which supports people to self-isolate.

**Competing Interests:** No competing interests were disclosed.

Reviewer Report 12 October 2020

<https://doi.org/10.21956/wellcomeopenres.17916.r40629>

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**Cheryl Cohen** 

Centre for Respiratory Diseases and Meningitis, National Institute for Communicable Diseases of the National Health Laboratory Service, Johannesburg, South Africa

**Impact of baseline cases of cough and fever on UK COVID-19 diagnostic testing rates: estimates from the Bug Watch community cohort study**

This paper uses data from a community cohort study to estimate the number of baseline cough and fever cases expected to occur in the 2020-2021 winter in the UK in order to infer the minimum COVID-19 testing capacity needed during the winter months. This is an important question and the approach taken is generally scientifically robust. The paper is nicely written and the approach is generally sound. I do have some suggestions below.

Major comments

The authors assume that the baseline rates of fever and cough in the upcoming winter will be similar to those of previous years with additional COVID-19-related burden superimposed. Data from the Southern Hemisphere 2020 winter however suggest that this may not be the case. Most Southern Hemisphere countries did not experience an influenza season in the 2020 winter and in many countries levels of ILI consultations were at all time low levels<sup>1</sup>. The authors should expand the abstract, introduction and discussion to consider this possibility further. It does not invalidate the relevance of the analysis but it should be clear that the projects presented may not be a true minimum estimate as it is possible that while COVID circulates other respiratory viruses may be at all-time low levels as may cases of fever and cough. The reason for the Southern Hemisphere observations are not known and it is also unclear what level of interventions will be in place to

control respiratory virus transmission during the upcoming UK winter season. Hence it is unclear whether the UK will see a reduction in respiratory illness. The authors should reposition the paper to include this possibility in introduction discussion and abstract.

This should also be included as a scenario in the analysis – i.e. baseline fever and cough is 50% OR 20% of historical numbers.

Methods: **UK testing demand due to baseline cough and fever cases** – the authors explore a range of scenarios for the proportion of cough and fever seeking testing. I think the explored ranges are reasonable but can the authors provide some context please (perhaps from other studies) on proportion of fever and cough cases which usually seek medical care (and perhaps get a sample for testing) in UK and any estimates (if they exist) or thoughts of how health seeking could increase (or decrease) in response to COVID to help contextualise which of these estimates they think more likely.

Could you use your study data from the summer period to look at the testing demand in the months which have already past? I.e. compare the rates for months which have past (March-August) from your study to the actual demand for testing experienced to date in the UK to see how the numbers compare and inform our thinking about how they might compare going forward. I.e. have the numbers to date been more or less than you would have predicted from your data?

#### Minor comments

Discussion line 3 – suggest change “will place a strain” to may place a strain.

Discussion – perhaps suggest some ways that UK could collect data on proportion of people with fever and cough who do get a test (e.g. through online platforms like your study) as these data may be useful to inform the public health response.

Discussion paragraph 5: “Our results show that total testing demand is relatively insensitive to COVID-19 transmission” this is an interesting result – are there any published studies which have found this – perhaps again from the Southern Hemisphere – I agree this is what would be expected but it would interesting to see if this happened anywhere. COVID detection rates in different settings could be helpful but would need to know the case definitions used for testing and health seeking behaviour which data are generally not available.

#### **References**

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**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?**

I cannot comment. A qualified statistician is required.

**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, viral respiratory illness.

**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 15 Jan 2021

**Max Eure**, Lancaster University, Lancaster, UK

Many thanks for the time you have spent reviewing our paper and your very helpful and constructive comments on the paper. We have tried to address all of the points you have raised and to update the paper as much as is reasonably possible within the rapidly changing context. There is now an additional analysis which explores a lower (73% lower) cough or fever incidence scenario based on preliminary estimates from the Virus Watch cohort study we are running at UCL. We provide numbered point by point responses to your comments below.

**Major comments**

**Reviewer comment 1:**

General - The authors assume that the baseline rates of fever and cough in the upcoming winter will be similar to those of previous years with additional COVID-19-related burden superimposed. Data from the Southern Hemisphere 2020 winter however suggest that this may not be the case. Most Southern Hemisphere countries did not experience an influenza season in the 2020 winter and in many countries levels of ILI consultations were at all time low levels<sup>1</sup>. The authors should expand the abstract, introduction and discussion to consider this possibility further. It does not invalidate the relevance of the analysis but it should be clear that the projects presented may not be a true minimum estimate as it is possible that while COVID circulates other respiratory viruses may be at all-time low levels as may cases of fever and cough. The reason for the Southern Hemisphere observations are not known and it is also unclear what level of interventions will be in place to control respiratory virus transmission during the upcoming UK winter season. Hence it is unclear whether the UK will see a reduction in respiratory illness. The authors should reposition the paper to include this possibility in introduction discussion and abstract. This should also be

included as a scenario in the analysis – i.e. baseline fever and cough is 50% OR 20% of historical numbers.

**Author response 1:**

Thank you for this important comment. We have now thoroughly addressed this by discussing the possibility of low levels of other respiratory viruses and the implications of this throughout the paper and by adding an additional analysis. In this analysis we explore a low cough or fever incidence scenario (73% lower incidence than 2018-2019 levels) based on preliminary estimates from the Virus Watch cohort study we are running at UCL.

**Reviewer comment 2:**

Methods - UK testing demand due to baseline cough and fever cases – the authors explore a range of scenarios for the proportion of cough and fever seeking testing. I think the explored ranges are reasonable but can the authors provide some context please (perhaps from other studies) on proportion of fever and cough cases which usually seek medical care (and perhaps get a sample for testing) in UK and any estimates (if they exist) or thoughts of how health seeking could increase (or decrease) in response to COVID to help contextualise which of these estimates they think more likely.

**Author response 2:**

We have added a new reference in the discussion section which estimates “that only about 40% of those who report classic COVID-19 symptoms go on to receive a test”. We then comment on the implications of this on COVID-19 control and our results, and stress the importance of future studies looking at test-seeking behaviour and comment on how they can be structured.

**Reviewer comment 3:**

Methods - Could you use your study data from the summer period to look at the testing demand in the months which have already past? I.e. compare the rates for months which have past (March-August) from your study to the actual demand for testing experienced to date in the UK to see how the numbers compare and inform our thinking about how they might compare going forward. I.e. have the numbers to date been more or less than you would have predicted from your data?

**Author response 3:**

Thank you very much for this interesting suggestion. However, given the length of the paper in its current form and to limit the number of analyses within it we have decided not to carry out this additional analysis.

**Minor comments****Reviewer comment 4:**

Discussion line 3 – suggest change “will place a strain” to may place a strain.

**Author response 4:**

We have added this suggestion.

**Reviewer comment 5:**

Discussion – perhaps suggest some ways that UK could collect data on proportion of people with fever and cough who do get a test (e.g. through online platforms like your study) as these data may be useful to inform the public health response.

**Author response 5:**

We have added a new reference in the discussion section which estimates “that only about 40% of those who report classic COVID-19 symptoms go on to receive a test”. We then comment on the implications of this on COVID-19 control and our results, and stress the importance of future studies looking at test-seeking behaviour and comment on how they can be structured.

**Reviewer comment 6:**

Discussion paragraph 5 - “Our results show that total testing demand is relatively insensitive to COVID-19 transmission” this is an interesting result – are there any published studies which have found this – perhaps again from the Southern Hemisphere – I agree this is what would be expected but it would interesting to see if this happened anywhere. COVID detection rates in different settings could be helpful but would need to know the case definitions used for testing and health seeking behaviour which data are generally not available.

**Author response 6:**

We have been unable to find any published studies which have evaluated the sensitivity of testing demand to COVID-19 transmission and do not think we can explore this issue further in the discussion.

**Competing Interests:** No competing interests were disclosed.