LFD mass testing in English schools: additional evidence of high test specificity

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Background:

Widespread testing for infectious SARS-CoV-2 infections with lateral flow devices (LFDs) was introduced to educational settings in England on 27 November 2020 for higher education, 4 January 2021 in all secondary schools and colleges, and 18 January 2021 in primary schools, school-based nurseries and maintained nursery schools [1]. Since 5 November 2020, more than 4 million LFD tests have been administered in education settings. There are, however, concerns that large scale use of LFDs may lead to an overwhelming amount of false positive test results, with detrimental consequences such as loss of face-to-face teaching amongst isolating students, and loss of working time amongst working parents.

Methods:

We used the weekly and nationally aggregated number of LFD tests (excluding unknown/void results) and positive LFD tests stratified by educational setting as reported by the NHS [1]. Data ta on secondary schools was further stratified by school/staff using age to determine each category. Tests in higher education could not be clearly distinguished by age and therefore comprise both staff and students. These tests were taken as part of the routine surveillance in educational settings among asymptomatic staff and pupils. From January 2021 schools were closed to all but the children of key workers while nurseries stayed open. In the majority of cases the tests were combined oral-nasal swabs not administered by trained healthcare staff, and the LFD test used was the Innova lateral flow antigen test.

We investigated the trajectory of test-positivity as measured by LFD in educational settings and compared it to the trajectory of test-positive cases from national routine surveillance for COVID-19.

We calculated a lower bound for the specificity of the LFD when used in educational settings in England by assuming that, at worst, all positive tests might be false positive. If in sample *i* (one week in a type of educational setting as given in the data set) x_i test results are positive among n_i tested, the probability of test specificity *s* being at most *s'*, with *p' = 1 - s'*, is given by

$$P(p > p'|x_i, n_i) = \int_{p'}^{1} Beta(p'', x_i + 1, n_i - x_i + 1)dp''$$

The probability of the test specificity being at most *s'* given all samples *i* is

$$P(p > p'|\{x_i, n_i\}) = \prod_i \int_{p'}^{1} Beta(p'', x_i + 1, n_i - x_i + 1)\, dp''$$

And therefore the probability of the test specificity being greater than *s'* given all observations is

$$P(s \geq s'|\{x_i, n_i\}) = 1 - \prod_i \int_{p'}^{1} Beta(p'', x_i + 1, n_i - x_i + 1)dp''$$

Results:
In total just over 4.6 million test results were reported as positive or negative, amongst which 10272 (0.22%) positive. LFD test-positivity in educational settings followed the general epidemic, indicating that a substantial proportion of LFD positives were likely true positives (Figure 1 and 2). Since the start of the latest lockdown on 5 January, primary schools and nurseries have had higher test-positivity ratios than secondary schools and colleges, but lower test-positivity ratios than higher education institutions. Secondary school students had consistently higher test positivity ratio than secondary school teachers. While test-positive rates were generally declining towards the end of the study period, in primary schools and nurseries test positivity rates increased in the last week (week starting 11 February).

We estimate that with 95% probability the specificity of the LFD testing in educational settings was greater than 99.93% This is substantially higher than a previously reported estimate of 99.61% (99.40 - 99.76) when swabs were taken by non-experts which, however, found that false positives test were showing weak indicator lines on the LFD and were generally negative if re-testing with LFD [2]. Our estimate implies that if the true prevalence is as low as 0.1% (or 0.5%) then more than 45% (or 80% at 0.5% prevalence) of test positives with LFD would be truly infected (assuming an LFD sensitivity of 80%, which is a conservative estimate for detecting infectiousness). Given our estimate we would expect a maximum 3254 (95% confidence) false positive tests among the over 4 million tests administered (including staff) until mid-February, implying detection of at least 7018 (95% confidence) true infections that could otherwise have gone undetected and transmitted further.

Conclusions:
LFD tests have even higher specificity than previously reported and potentially even higher than the lower bound we could estimate here. Combined with their high sensitivity for detecting infectious infections [3] LFD tests can therefore play an important part of pandemic mitigation strategies in educational settings and elsewhere. Nevertheless, as SARS-CoV-2 infection prevalence declines the proportion of true positives among the test positives will similarly decrease and so will the utility of mass testing compared to its societal and monetary cost. Disaggregated data by educational institution could further improve the precision of our estimates and help better evaluate the expected rate of false positives at a given level of prevalence.

Given that nurseries have been open throughout the current restrictions implemented on 5 January, the greater level of prevalence in nurseries and primary schools than in secondary schools, combined with a hint of a recent uptick, warrants further monitoring.

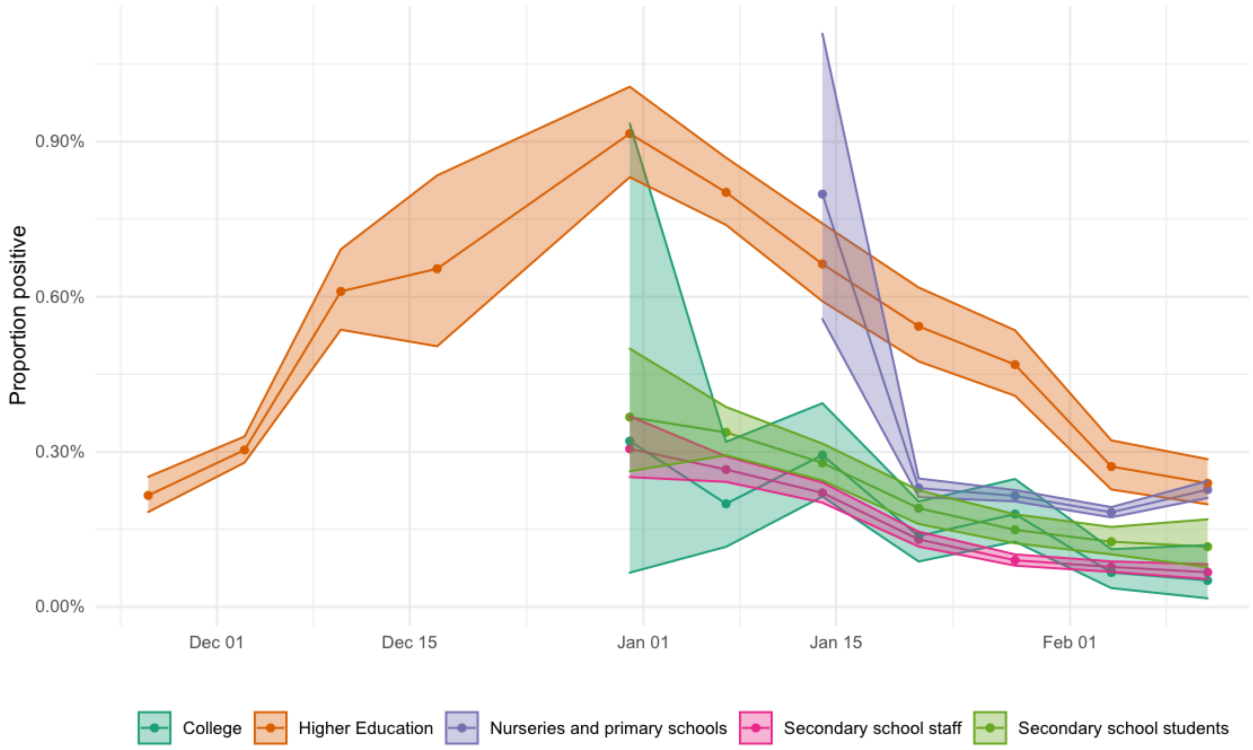

Figure 1: LFD test positivity as proportion of all LFD tests conducted in different settings (mean: points and lines, 95% exact binomial confidence intervals: shaded area).

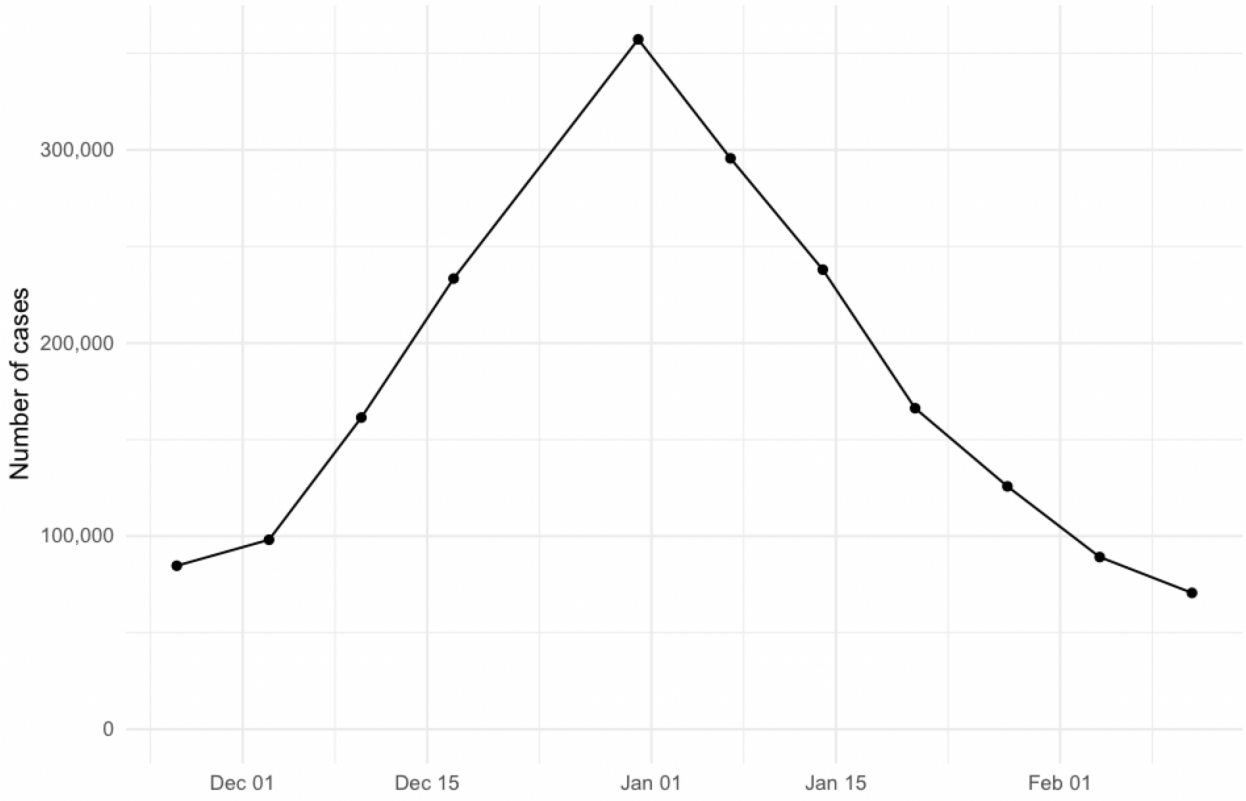

Figure 2: Total weekly number of test-positive cases in England by date of specimen reported via the Covid-19 surveillance system (https://coronavirus.data.gov.uk/).

Code availability:

All the code required to reproduce Fig. 1 and the estimates of a lower bound on specificity is available at https://github.com/epiforecasts/covid19.lfd.education

References:

[1] https://www.gov.uk/government/publications/nhs-test-and-trace-england-statistics-11-february-to-17-february-2021
[2] Preliminary report from the Joint PHE Porton Down & University of Oxford SARS-CoV-2 test development and validation cell: rapid evaluation of lateral flow viral antigen detection devices (LFDs) for mass community testing. 8 Nov 2020. https://www.ox.ac.uk/sites/files/oxford/media_wysiwyg/UK%20evaluation_PHE%20Porton%20Down%20%20University%20of%20Oxford_final.pdf.
[3] Comparative performance of SARS-CoV-2 lateral flow antigen tests demonstrates their utility for high sensitivity detection of infectious virus in clinical specimens

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