A1 Appendix

The impact of co-circulating pathogens on SARS-CoV-2/COVID-19 surveillance

How concurrent epidemics may introduce bias and decrease the observed SARS-CoV-2 percent positivity.

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## S1. Transmission model

### S1.1 Model parameters

| Parameter | Meaning | Value | Source |
|-----------|---------|-------|--------|
| $R_{01}$ | SARS-CoV-2 basic reproduction number in the general community on 01/09/2020 at the time of school reopening | 1.4 | Value from the time of school opening on 01/09/2020 [1] |
| $R_{02}$ | Virus 2 basic reproduction number at the time of school reopening | 1.9 | Assumed, [2] |
| $\gamma_1$ | Recovery rate for SARS-CoV-2 | $1/7 \text{ day}^{-1}$ | [3] |
| $\gamma_2$ | Recovery rate for virus 2 | $1/5 \text{ day}^{-1}$ | [2] |
| $\alpha_1$ | Infectiousness onset rate for SARS-CoV-2 | $1/2.9 \text{ day}^{-1}$ | [4] |
| $\alpha_2$ | Infectiousness onset rate for virus 2 | $1/2 \text{ day}^{-1}$ | [2] |
| $s_1$ | Proportion of infected with SARS-CoV-2 that is symptomatic at the time of testing | 0.5 | [5] |
| $s_2$ | Proportion of infected with virus 2 that is symptomatic at the time of testing | 0.7 | Assumed |
| $p_1, p_2$ | Proportion of symptomatic individuals infected with either pathogen that gets tested | 0.6 | Assumed |
| $s$ | Proportion of individuals that is symptomatic, but negative among all PCR tests (before virus 2 outbreak) | 0.11 | Estimated from data during weeks 33 and 34; Data are from Ref. [6] |
| $b$ | Proportion of the total population $N$ getting tested daily (total daily PCR tests) | 0.003 | Estimated from data during weeks 35-44; Data are from Ref. [6] |
| $T_b$ | Symptomatic testing baseline (getting tested daily for SARS-CoV-2, but truly negative for SARS-CoV-2) | $b*N*s$ | Calculated using estimated values $s$ and $b$ |
| $\tau$ | Number of contacts getting tested on average per one positive test during September 2020 | 3 | [5] |
| $d$ | Contact tracing delay between a positive test and testing their contacts | 2 days | Assumed |
| $m$ | Proportion of multiplex PCR tests | 0.001 | Varied |
| $c$ | Proportion of SARS-CoV-2 PCR tests | $1-m$ | Calculated from $m$ |
| $s_{pcr}$ | SARS-CoV-2 PCR test sensitivity | 95% | [7] |
| $s_m$ | Multiplex PCR test sensitivity | 90% | Assumed the lower end of multiplex FilmArray Respiratory Panel [8, 9] |
S1.2 Interaction parameters

Four interaction parameters modulating the pathogen’s transmissibility

| Pathogen | Baseline transmissibility | Change in infectiousness of co-infected classes | Probability of acquisition of a second infection following a first infection |
|----------|---------------------------|-----------------------------------------------|--------------------------------------------------------------------------|
| Virus 1  | $\beta_1$                  | $\sigma_1$ change in infectiousness of Virus 2 if co-infected with Virus 1 | $\delta_1$ = probability of acquiring Virus 2 when already infected with Virus 1 |
| Virus 2  | $\beta_2$                  | $\sigma_2$ change in infectiousness of Virus 1 if co-infected with Virus 2 | $\delta_2$ = probability of acquiring Virus 1 when already infected with Virus 2 |

We assume baseline scenario, no interaction between two pathogens: $\sigma_1 = \sigma_2 = \delta_1 = \delta_2 = 1$ and that recovery rates of dually infected compartment are: $\gamma_1 = \gamma_2$ and $\gamma_3 = \gamma_4$

$\beta_1 = R_{01} \cdot \gamma_1$

$\beta_2 = R_{02} \cdot \gamma_2$

S1.3 Forces of infection

\[
\lambda_1 = \beta_1 \left( \frac{X_{IS}}{N} + \sigma_2 \frac{X_{I_1 I_2}}{N} + \sigma_2 \frac{X_{I_2 I_1}}{N} + \frac{X_{IR}}{N} + \sigma_2 \frac{X_{IE}}{N} \right) \\
\lambda_2 = \delta_2 \beta_1 \left( \frac{X_{IS}}{N} + \sigma_2 \frac{X_{I_1 I_2}}{N} + \sigma_2 \frac{X_{I_2 I_1}}{N} + \frac{X_{IR}}{N} + \sigma_2 \frac{X_{IE}}{N} \right) \\
\lambda_{21} = \delta_2 \beta_1 \left( \frac{X_{IS}}{N} + \sigma_2 \frac{X_{I_1 I_2}}{N} + \sigma_2 \frac{X_{I_2 I_1}}{N} + \frac{X_{IR}}{N} + \sigma_2 \frac{X_{IE}}{N} \right) \\
\lambda_2 = \beta_2 \left( \frac{X_{SI}}{N} + \sigma_1 \frac{X_{I_1 I_2}}{N} + \sigma_1 \frac{X_{I_2 I_1}}{N} + \frac{X_{RI}}{N} + \sigma_1 \frac{X_{EI}}{N} \right) \\
\lambda_{12} = \delta_1 \beta_2 \left( \frac{X_{SI}}{N} + \sigma_1 \frac{X_{I_1 I_2}}{N} + \sigma_1 \frac{X_{I_2 I_1}}{N} + \frac{X_{RI}}{N} + \sigma_1 \frac{X_{EI}}{N} \right)
\]

S1.4 Transmission model equations

Susceptible:

\[
\frac{dX_{SS}}{dt} = -\lambda_1 X_{SS} - \lambda_2 X_{SS}
\]

Exposed:

\[
\frac{dX_{ES}}{dt} = +\lambda_1 X_{SS} - \alpha_1 X_{ES}
\]

\[
\frac{dX_{SE}}{dt} = +\lambda_2 X_{SS} - \alpha_2 X_{SE}
\]
Infected:
\[
\frac{dX_{IS}}{dt} = +\alpha_1 X_{ES} - \lambda_{12} X_{IS} - \gamma_1 X_{IS}
\]
\[
\frac{dX_{SI}}{dt} = +\alpha_2 X_{SE} - \lambda_{21} X_{SI} - \gamma_2 X_{SI}
\]

Infected with one virus, exposed to the other:
\[
\frac{dX_{IE}}{dt} = +\lambda_{12} X_{IS} - \alpha_2 X_{IE} - \gamma_1 X_{IE}
\]
\[
\frac{dX_{EI}}{dt} = +\lambda_{21} X_{SI} - \alpha_1 X_{EI} - \gamma_2 X_{EI}
\]

Double infected:
\[
\frac{dX_{I1l2}}{dt} = +\alpha_2 X_{IE} - \gamma_{12} l_{12} - \gamma_1 X_{I1l2}
\]
\[
\frac{dX_{I2l1}}{dt} = +\alpha_1 X_{EI} - \gamma_{21} l_{21} - \gamma_2 X_{I2l1}
\]

Recovered from one virus:
\[
\frac{dX_{RS}}{dt} = +\gamma_1 X_{IS} - \lambda_2 X_{RS}
\]
\[
\frac{dX_{SR}}{dt} = +\gamma_2 X_{SI} - \lambda_1 X_{SR}
\]

Recovered from one virus, exposed to the other:
\[
\frac{dX_{RE}}{dt} = +\lambda_2 X_{RS} - \alpha_2 X_{RE} + \gamma_1 X_{IE}
\]
\[
\frac{dX_{ER}}{dt} = +\lambda_1 X_{SR} - \alpha_1 X_{ER} + \gamma_2 X_{EI}
\]

Recovered from one virus, infected with the other:
\[
\frac{dX_{RI}}{dt} = +\alpha_2 X_{RE} - \gamma_2 X_{RI} + \gamma_1 X_{I1l2}
\]
\[
\frac{dX_{IR}}{dt} = +\alpha_1 X_{ER} - \gamma_1 X_{IR} + \gamma_2 X_{I2l1}
\]
Recovered from both viruses:

\[ \frac{dX_{R_1,R_2}}{dt} = +\gamma_{12}X_{I_1,I_2} + \gamma_2X_{R_1} + \gamma_{21}X_{I_2,I_1} + \gamma_1X_{I_R} \]

### S1.5 Simulation study

**Initialization.** The modelling study was simulated on the population of 67 million people. Model was initialized assuming no interaction scenario, with 6% of the population being in \(X_{RS}\) compartment [10] and 70% of the population in \(X_{SR}\) compartment allowing for virus-2 outbreak to finish within two-month period. SARS-CoV-2 was initialized with 12,060 individuals in the Exposed (\(X_{ES}\) compartment and 42,210 individuals in the Infected (\(X_{IS}\) compartment from the week before. Virus-2 was introduced on day 7 with 300,000 individuals in total, with 270,000 being in the Infected (\(X_{SI}\) compartment and 30,000 individuals being in Exposed (\(X_{SE}\) compartment.

We simulated an outbreak of virus-2 for 8 weeks. Parameter values used in the study correspond to the real time values reported right before and during the time when a decrease in symptomatic percent positive of SARS-CoV-2 was observed in the French population – starting in the first week of September, the time of school opening. Two pathogens had different transmission characteristics at the time of an outbreak of virus-2 (SARS-CoV-2: \(R_0 = 1.4, \gamma_1 = 1/7\) day\(^{-1}\), \(\alpha_1 = 1/2.9\) day\(^{-1}\); virus-2: \(R_0 = 1.9, \gamma_2 = 1/5\) day\(^{-1}\), \(\alpha_2 = 1/2\) day\(^{-1}\)) with virus-2 having a greater basic reproduction number (\(R_0\)) because of its ability to spread easily among school children, and a faster recovery rate (i.e., shorter infectious period).  

### S2. Testing model

#### S2.1 Number of tests

Baseline number of symptomatic tests (\(T_b\)) is calculated by assuming that a constant proportion of population \(N\) is tested on a daily basis (\(b\)) with a proportion of this population being symptomatic (\(s\)) due to reasons other than COVID-19 infection or virus-2 outbreak. Baseline symptomatic tests are assumed to be negative for both SARS-CoV-2 and virus-2.

\[ T_b = b * N * s \]

Number of tests due to symptomatic individuals infected with SARS-CoV-2 is calculated by assuming only a proportion of population infected with SARS-CoV-2 will present symptoms (\(s_1\)) and request testing (\(p_1\)).

\[ T_{COV}(t) = s_1 * p_1 * N_1(t) \]

with \(N_1\) being the incident number of people infectious with SARS-CoV-2.

\[ N_1(t) = \int_{t-1}^{t} (\alpha_1X_{ES}(t) + \lambda_{12}X_{IS}(t) + \alpha_1X_{EI}(t) + \alpha_2X_{IE}(t) + \alpha_1X_{ER}(t) + \gamma_1X_{R_1}(t) + \gamma_2X_{I_2,I_1}(t))dt \]
Similar approach was taken when calculating number of tests due to symptomatic individuals infected with virus-2 assuming that only a proportion of population infected with virus-2 present symptoms (s_2) and requests testing (p_2) for COVID-19:

\[ T_{V2}(t) = s_2 * p_2 * N_2(t) \]

where \( N_2 \) is the incident number of people infectious with virus-2, not including double infected individuals.

\[ N_2(t) = \int_{t-1}^{t} (a_2X_{SE}(t) + \lambda_2X_{SI}(t) + \alpha_2X_{RE}(t) + \gamma_1X_{I_2I_2})dt \]

Double infected individuals are excluded from virus-2 count because ultimately, they will be counted towards positive SARS-CoV-2 cases and will not be excluded from the corrected total of daily tests when we conduct correction of the percent positive.

The number of symptomatic tests generated by contact tracing and testing around confirmed infected cases with SARS-CoV-2 on a day \( t \), assuming a contact tracing delay \( d \) between a positive case and testing their contacts, is calculated as following:

\[ T_{CONTACTS}(t - d) = s_1 * \tau * p_1 * N_1(t - d) \]

where \( \tau \) represents number of contacts tested per one positive case, on average. We considered contacts of both symptomatic and asymptomatic confirmed index cases but only included symptomatic contacts in the total number of symptomatic tests. Among these symptomatic tests generated by contact tracing and testing around confirmed infected cases, the proportion of truly infected with SARS-CoV-2 is assumed to scale with the prevalence of SARS-CoV-2 in the population at the date of the test.

Prevalence of SARS-CoV-2 in the population \( prev(t) \) at time \( t \) is the proportion of population infected with SARS-CoV-2 at time \( t \), it can be estimated by:

\[ prev(t) = \frac{(X_{I2}(t) + X_{IE}(t) + X_{I_2I_2}(t) + X_{I_2I_2}(t) + X_{R_1R_2}(t))}{N} \]

Number of SARS-CoV-2 positive tests among symptomatic individuals \( T_+ \) on a given day \( t \) is calculated according to the following equation:

\[ T_+(t) = (1 - m) * s_{pcr} * T_{COV}(t) + m * s_m * T_{COV}(t) + prev(t) * s_{pcr} * T_{CONTACTS}(t - d) \]

where \( m \) represents the proportion of multiplex PCR tests among total tests conducted on symptomatic individuals, \( s_{pcr} \) and \( s_m \) represent sensitivity of PCR SARS-CoV-2 test and PCR multiplex tests, respectively, with \( prev \) representing prevalence of SARS-CoV-2 in the population on a given day \( t \).

In case of the effective percent positive \( P_{E+}(t) \) based on a single-pathogen SEIR transmission model, incident number of people infectious with SARS-CoV-2 is:

\[ N_1(t) = \int_{t-1}^{t} (\alpha_1X_{ES}(t))dt \]
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while the prevalence of SARS-CoV-2 in the population at time $t$ with single virus circulating is based on $X_{IS}$ compartment only and is calculated by:

$$\text{prev}_E(t) = \frac{X_{IS}(t)}{N}$$

Therefore, in case of the effective percent positivity, number of SARS-CoV-2 positive tests among symptomatic individuals is:

$$T_+(t) = (1 - m) \cdot s_{pcr} \cdot T_{COV}(t) + m \cdot s_m \cdot T_{COV}(t) + \text{prev}_E(t) \cdot s_{pcr} \cdot T_{CONTACTS}(t - d)$$

Considering that there is no secondary pathogen present in the population, number of tests due to symptomatic individuals infected with virus-2 is zero, $T_{V2}(t) = 0$, and the total number of tests $T$ for SARS-CoV-2 among symptomatic individuals on a given day $t$ is given by:

$$T(t) = T_b + T_{COV}(t) + T_{CONTACTS}(t - d)$$

### S2.2 Correction of the observed SARS-CoV-2 symptomatic percent positive

We proposed a corrected version of the symptomatic percent positive of SARS-CoV-2 based on the results of multiplex PCR testing:

The proportion of symptomatic virus-2 confirmed positive cases among all multiplex PCR tests ($T_m$) is given by:

$$\text{prop}_{V2+}(t) = \frac{T_{V2+}(t)}{T_m(t)}$$

where $T_{V2}$ is the confirmed positive symptomatic virus 2 cases and $T_m$ is the number of symptomatic multiplex PCR tests.

### S2.3 Stochastic reporting of test results

The observed number of positive tests for SARS-CoV-2 ($T_{COV}$) and virus-2 ($T_{V2+}$) respectively, were modelled as follows:

$$T_{COV}(t) \sim \text{Binomial}(T_{pcr}(t), s_{pcr})$$

$$T_{V2+}(t) \sim \text{Binomial}(T_m(t), p(t) \cdot s_m)$$

where $s_{pcr}$ and $s_m$ represent sensitivities of PCR and multiplex tests, respectively; $T_{pcr}$ and $T_m$ represent the number of symptomatic PCR SARS-CoV-2 tests on day $t$ and the number of symptomatic multiplex PCR tests on day $t$, respectively; and $p(t)$ represents the true probability of being infected with virus-2 among tested symptomatic individuals:

$$p(t) = \frac{T_{V2}(t)}{(T_b + T_{COV}(t) + T_{V2}(t))}$$
S3. Sensitivity analyses

S3.1 Impact of sensitivity of multiplex PCR tests ($s_m$) on the correction of the observed SARS-CoV-2 percent positive

**Figure S1. Impact of multiplex PCR test sensitivity ($s_m$) on the correction of the observed SARS-CoV-2 percent positive.** Correction of the observed percent positive for SARS-CoV-2 (red dashed line, grey areas represent 95% CIs) depends on the sensitivity of the multiplex PCR assays ($s_m$). Figure shows simulations results with a) 0.95, b) 0.90, c) 0.80, and d) 0.60 values of $s_m$. $s_m = 0.95$ will provide a correction that closely follows effective percent positive, while tests with lower $s_m$ provide a correction that is more distant than the effective percent positive. For all simulations, we fixed the sensitivity of PCR SARS-CoV-2 test to $s_{pcr} = 0.95$ and the proportion of multiplex PCR tests carried out to $m = 0.001$. 

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**a) $s_m = 0.95$**

**b) $s_m = 0.90$**

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**c) $s_m = 0.80$**

**d) $s_m = 0.60$**
S3.2 Impact of the proportion of multiplex PCR tests used \((m)\) among all tests conducted on symptomatic individuals on the correction of the observed SARS-CoV-2 percent positive

**a)** \(m = 0.0005\) (1 multiplex per 2,000 tests)

**b)** \(m = 0.001\) (1 multiplex per 1,000 tests)

**c)** \(m = 0.002\) (1 multiplex per 500 tests)

**d)** \(m = 0.005\) (1 multiplex per 200 tests)

Figure S2. Impact of a range of proportions of multiplex PCR tests used \((m)\) among all tests conducted on the symptomatic individuals on the correction of the observed symptomatic SARS-CoV-2 percent positive. Quality of the correction of the observed SARS-CoV-2 percent positive (red dashed line, grey areas represent 95% CIs) depends on the number (i.e., proportion) of multiplex PCR tests used \((m)\) on symptomatic individuals. Figure shows simulations with a) 0.005, b) 0.001, c) 0.002, and d) 0.005 values of \(m\). Greater values of \(m\) provide better quality of the correction of the observed SARS-CoV-2 percent positive. For all simulations, we fixed the sensitivity of PCR SARS-CoV-2 test to \(s_{pcr} = 0.95\) and the sensitivity of multiplex PCR test to \(s_m = 0.90\).
S3.3 Impact of sensitivity of SARS-CoV-2 PCR tests ($s_{pcr}$) on the correction of the observed SARS-CoV-2 percent positive

**Figure S3. Impact of SARS-CoV-2 PCR test sensitivity ($s_{pcr}$) on the correction of the observed SARS-CoV-2 percent positive.** Correction of the observed percent positive for SARS-CoV-2 (red dashed line, grey areas represent 95% CIs) does not depend on the sensitivity of the SARS-CoV-2 PCR assays ($s_{pcr}$). Figure shows simulations results with a) 0.95, b) 0.90, c) 0.80, and d) 0.60 values of $s_{pcr}$. Successful detection of positive SARS-CoV-2 cases and overall observed percent positivity depends on $s_{pcr}$. However, the correction quality is not affected by this parameter. For all simulations, we fixed the sensitivity of multiplex PCR test to $s_m = 0.90$ and the proportion of multiplex PCR tests carried out to $m = 0.001$. 

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**a) $s_{pcr} = 0.95$**

**b) $s_{pcr} = 0.90$**

**c) $s_{pcr} = 0.80$**

**d) $s_{pcr} = 0.60$**
S3.4 Impact of the proportion of individuals infected with virus-2 that is symptomatic at the time of testing ($s_2$) on the correction of the observed SARS-CoV-2 percent positive

**a) $s_2 = 0.8$**

**b) $s_2 = 0.7$**

**c) $s_2 = 0.6$**

**d) $s_2 = 0.5$**

Figure S4. Impact of a range of proportion values for individuals infected with virus-2 that are symptomatic at the time of testing ($s_2$) on the correction of the observed SARS-CoV-2 percent positive. Correction of the observed percent positive for SARS-CoV-2 (red dashed line, grey areas represent 95% CIs) does not depend on the proportion of infected with virus-2 that is symptomatic at the time of testing ($s_2$). Therefore, the correction quality is not affected by this parameter. However, the gap between the effective and observed percent positive decreases with the decreasing proportion of infected with virus-2 that is symptomatic since smaller number of symptomatic individuals infected with virus-2 request SARS-CoV-2 test. Figure shows simulations results with a) 0.8, b) 0.7, c) 0.6, and d) 0.5 values of $s_2$. For all simulations, we fixed the sensitivity of PCR SARS-CoV-2 test to $s_{pcr} = 0.95$, sensitivity of multiplex PCR test to $s_m = 0.90$, and the proportion of multiplex PCR tests carried out to $m = 0.001$. 
S3.5 Impact of virus-2 $R_0$ on the correction of the observed SARS-CoV-2 percent positive

**Figure S5. The impact of varying $R_0$ of virus-2.** Correction of the observed percent positive for SARS-CoV-2 (red dashed line, grey areas represent 95% CIs) does not depend on $R_0$ of virus-2 and the correction quality is not affected by this parameter. However, the gap between the effective and observed percent positive increases with the increasing value of $R_0$ and vice versa. Percent increase in SARS-CoV-2 testing demand (solid red line) is affected in the similar manner. Figure shows simulation results with $R_0$ values of a) 1.4: The observed SARS-CoV-2 symptomatic percent positive underestimated the effective percent positive by up to 2.4% (19% relative decrease). Daily SARS-CoV-2 testing demand increased up to 19.2%; and b) 2.5: The observed SARS-CoV-2 percent positive among symptomatic individuals underestimated the effective percent positive by up to 3.6% (27.8% relative decrease). Daily SARS-CoV-2 testing demand increased up to 27.9%.
S3.6 Impact of the initial proportion of the population immune to SARS-CoV-2 on the correction of the observed SARS-CoV-2 percent positive

**a) 30% immune to SARS-CoV-2**

- **A**
  - Number of infected people
  - Circulating pathogens: SARS-CoV-2, Virus-2

- **B**
  - SARS-CoV-2 test demand (symptomatic):
    - Positive testing (Ts)
    - SARS-CoV-2
    - Control testing
    - Virus-2
  - Number of tests

- **C**
  - Percent positive (%)

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**b) 50% immune to SARS-CoV-2**

- **A**
  - Number of infected people
  - Circulating pathogens: SARS-CoV-2, Virus-2

- **B**
  - SARS-CoV-2 test demand (symptomatic):
    - Positive testing (Ts)
    - SARS-CoV-2
    - Control testing
    - Virus-2
  - Number of tests

- **C**
  - Percent positive (%)

**Circulating pathogens:**
- SARS-CoV-2 (Effective percent positive)
- SARS-CoV-2 and Virus-2 (Observed percent positive)
- SARS-CoV-2 and Virus-2 (Corrected percent positive using multiplex PCR assays)
Figure S6. Impact of the initial proportion of the population immune to SARS-CoV-2. Correction of the observed percent positive for SARS-CoV-2 (red dashed line, grey areas represent 95% CIs) does not depend on the initial proportion of the population immune to SARS-CoV-2. The correction quality is not affected by this parameter. However, the gap between the effective and observed percent positive decreases with the increasing initial proportion of the population immune to SARS-CoV-2. On the other hand, percent increase in SARS-CoV-2 testing demand (solid red line) experiences slight increase with the increasing initial proportion of the population immune to SARS-CoV-2. Figure shows simulation results with increasing proportion of the population being immune to SARS-CoV-2: a) 30% immune to SARS-CoV-2 ($X_{RS} = 0.06; X_{SR} = 0.46; X_{RR} = 0.24$): The observed SARS-CoV-2 percent positive among symptomatic tests underestimated the effective percent positive by up to 2.2% (24.9% relative decrease). Daily SARS-CoV-2 testing demand increased up to 25.1%. b) 50% immune to SARS-CoV-2 ($X_{RS} = 0.06; X_{SR} = 0.26; X_{RR} = 0.44$): The observed SARS-CoV-2 percent positive among symptomatic tests underestimated the effective percent positive by up to 1.55% (25.8% relative decrease). Daily SARS-CoV-2 testing demand increased up to 26.6%. c) 70% immune to SARS-CoV-2 ($X_{RS} = 0.06; X_{SR} = 0.06; X_{RR} = 0.64$): The observed SARS-CoV-2 percent positive among symptomatic tests underestimated the effective percent positive by up to 0.93% (25.5% relative decrease). Daily SARS-CoV-2 testing demand increased up to 28.4%. 

**Figure S6**
S3.7 Impact of the initial proportion of the population immune to SARS-CoV-2 and to virus-2 on the correction of the observed SARS-CoV-2 percent positive

50% immune to SARS-CoV-2 and 30% immune to virus-2

Figure S7. Impact of the initial proportion of the population immune to SARS-CoV-2 and to virus-2. Correction of the observed percent positive for SARS-CoV-2 (red dashed line, grey areas represent 95% CIs) does not depend on the initial proportion of the population immune to SARS-CoV-2. The correction quality is not affected by this parameter. However, both the gap between the effective and observed percent positive and the percent increase in SARS-CoV-2 testing demand (solid red line) increase with the increasing initial proportion of the population immune to SARS-CoV-2 and decreasing initial proportion of the population immune to virus-2. Figure shows simulation results with 30% and 50% of the population being immune to SARS-CoV-2 and virus-2, respectively ($X_{RS} = 0.26; X_{SR} = 0.46; X_{RR} = 0.04$). The observed SARS-CoV-2 percent positive among symptomatic tests underestimated the effective percent positive by up to 3.8% (39.9% relative decrease). Daily SARS-CoV-2 testing demand increased up to 36.6%.
S4. Age-structured transmission model

To test how an increase in testing demand and the correction of the observed percent positive might differ in different age groups assuming that one age group has higher transmission of virus-2, we divided transmission model into two age groups, children and adults, assuming children (<15 years old) make up 20% of the population. We assumed that the acquisition rate of virus-2 is three times higher in children than in adults, while keeping all the other parameters the same. Model assumes both within-group and between-group transmission of both viruses.

Transmission model equations for both age groups remained the same as in the original model and the equations for forces of infection were adjusted accordingly.

Maintaining $R_{02} = 1.9$, we assume:

$$1.9 = 0.2 * R_{02}^{(to \ children)} + 0.8 * R_{02}^{(to \ adults)}$$

We set $R_{02}^{(to \ adults)} = 1.4$ and $R_{02}^{(to \ children)} = 3 * R_{02}^{(to \ adults)}$

Therefore, acquisition rates are fixed as follows:

$$\beta_2^{(a)} = 0.28$$
$$\beta_2^{(c)} = 3 * \beta_2^{(a)}$$

S4.1 Forces of infection

Children:

$$\lambda_1^{(c)} = \beta_1^{(c)} \left( \frac{X_{I_2}^{(c)} + X_{I_R}^{(c)} + X_{I_1}^{(c)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{1}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right) + \sigma_2 \left( \frac{X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right)$$

$$\lambda_2^{(c)} = \delta_2 \beta_1^{(c)} \left( \frac{X_{I_2}^{(c)} + X_{I_R}^{(c)} + X_{I_1}^{(c)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right) + \sigma_2 \left( \frac{X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right)$$

$$\lambda_3^{(c)} = \delta_3 \beta_1^{(c)} \left( \frac{X_{I_2}^{(c)} + X_{I_R}^{(c)} + X_{I_1}^{(c)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right) + \sigma_2 \left( \frac{X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right)$$

Adults:

$$\lambda_1^{(a)} = \beta_1^{(a)} \left( \frac{X_{I_2}^{(c)} + X_{I_R}^{(c)} + X_{I_1}^{(c)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right) + \sigma_2 \left( \frac{X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{12}}^{(c)} + X_{I_{12}}^{(a)} + X_{I_{I_2}}^{(c)} + X_{I_{I_2}}^{(a)}}{N} \right)$$
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\[
\lambda_{21}^{(a)} = \delta_2 \beta_1^{(a)} \left( \frac{X_{Ic}^{(c)} + X_{Ic}^{(a)} + X_{Ic}^{(a)} + X_{Ic}^{(a)}}{N} \right) + \sigma_2 \left( \frac{X_{Ic}^{(c)} + X_{Ic}^{(a)} + X_{Ic}^{(a)} + X_{Ic}^{(a)} + X_{Ic}^{(a)}}{N} \right)
\]

\[
\lambda_2^{(a)} = \beta_2^{(a)} \left( \frac{X_{Sl}^{(c)} + X_{Sl}^{(a)} + X_{Sl}^{(a)} + X_{Sl}^{(a)}}{N} \right) + \sigma_1 \left( \frac{X_{Sl}^{(c)} + X_{Sl}^{(a)} + X_{Sl}^{(a)} + X_{Sl}^{(a)} + X_{Sl}^{(a)}}{N} \right)
\]

\[
\lambda_{12}^{(a)} = \delta_1 \beta_2^{(a)} \left( \frac{X_{Sl}^{(c)} + X_{Sl}^{(a)} + X_{Sl}^{(a)} + X_{Sl}^{(a)}}{N} \right) + \sigma_1 \left( \frac{X_{Sl}^{(c)} + X_{Sl}^{(a)} + X_{Sl}^{(a)} + X_{Sl}^{(a)} + X_{Sl}^{(a)}}{N} \right)
\]

Figure S8. Percent increase in SARS-CoV-2 testing demand in children and adults assuming virus-2 acquisition rate in children is higher than in adults. If we assume that virus-2 has three times higher acquisition rate in children than in adults where children (<15 years old) represent 20% of the total population, sensitivity analyses show that testing demand in children increased up to 36.4%, while in adults testing demand increased up to 19%.
Figure S9. Correction of the observed SARS-CoV-2 percent positive in children and adults with different proportion of multiplex tests: 

**a)** $m = 0.001$ (1 multiplex test per 1,000 symptomatic individuals): 

**b)** $m = 0.005$ (1 multiplex test per 200 symptomatic individuals): 

If acquisition rate of virus-2 is three times higher in children than in adults while keeping all the other parameters the same, underestimation of the observed SARS-CoV-2 percent positive (grey solid line) will be more pronounced in this age group. However, since children age group is much smaller in number and represents 20% of the total population, proportion $m$ of multiplex tests in this age group should be higher ($m=0.005$; 1 multiplex test per 200 symptomatic children) to achieve the correction of the similar quality obtained for the adults.
S5. Rhinovirus circulation in France

Figure S10. Detection of rhinovirus circulation in France from Sept 7 to Oct 26, 2020. Data are from Ref. [11]. Blue shaded part of the column represents number of multiplex tests positive for rhinovirus (numerator value) out of total number of multiplex tests (denominator value) conducted per week. French Sentinels physicians (general practitioners and pediatricians) conducted nasopharyngeal swabs among acute respiratory infection (ARI) cases seen in the consultation to test for the various respiratory viruses. This surveillance indicates active circulation of the virus over the study period.

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