RESEARCH LUXEMBOURG
COVID-19 Task Force

Midterm projections of the COVID-19 epidemic in Luxembourg regarding future deconfinement measures

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Disclaimer:
This report is based on the developed Covid-19 model for Luxembourg. The simulations shown are based on model version 3 and the currently available data (as of June 15th, 2020). In this respect, the presented results are to be interpreted within the framework of the stated assumptions and current data situation. The further development of the epidemic and the corresponding data as well as new scientific knowledge can lead to future model adjustments. For this purpose, the current developments will be further monitored and continuously compared with the underlying assumptions.

This document presents simulations on the midterm development of the Covid-19 epidemic in Luxembourg over the next few months. In particular the potential effects of

• school openings after the holidays,

• large private events such as weddings and

• the Large-Scale Testing (LST)

on the course of the epidemic are analyzed in dependence on various measures such as social distancing and test strategies. For this analysis, the various scenarios are simulated with the Luxembourg Covid-19 model (version 3) in addition to a baseline scenario that reflects the current deconfinement situation. Model description and reference scenario are shown in Section 1.

For the analysis of **school operations** (Section 2), different scenarios for school opening after the summer break are considered and compared in respect as to how

• divided classes

• social distancing

• Large-scale testing (LST) and optimized subgroup testing ("mesh testing"), i.e. the continuous monitoring of the population as well as

• contact tracing of positive cases

can influence the epidemic dynamics. The analysis shows that for **teaching in the entire class during the next school year, social distancing is still recommended and that contact tracing of active cases is essential to suppress a significant second wave.** Given the current status (20.06.2020) with an effective reproduction number (R) of 1.02 again which is above 1 for the first time since March 27, a second wave in Luxembourg is a very likely scenario. Measures must therefore be taken to prevent a second confinement under any circumstances. Mitigation through social distancing can be further improved with the help of the large-scale testing and efficient "mesh testing".

Finally, a brief analysis is given, which shows that teaching in the entire class during the last two school weeks of the current school year has no essential influence on the course of the epidemic.

The effect of **large private events** (such as family celebrations, especially weddings) is described in Section 3, considering different frequencies, number of guests and efficiency of social distance. The results indicate that these private events can have a significant influence on a second wave, in particular if social distancing measures are not implemented.

A first systematic analysis of the **large-scale testing (LST)** is given in Section 4, which shows that LST is a suitable means of suppressing the 2nd wave and that efficiency can be increased by defining subgroups. Thereby it is essential to not exceed the contact tracing capacity and therefore social distancing is still an important aspect in epidemic containment.

As in the previous analysis, special attention is paid to the stressors in the health system, with the capacity of the intensive care beds in particular being included as an essential limiting factor.

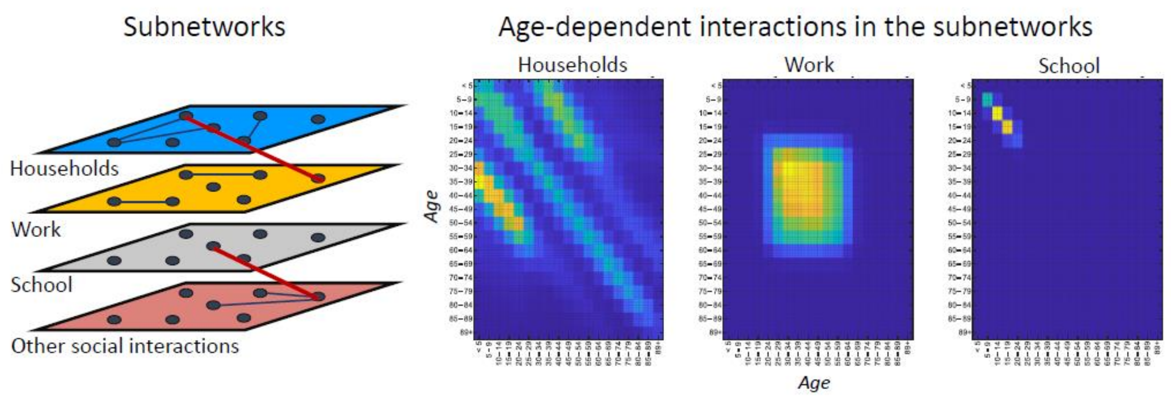
1. Description of the model (version 3) und the reference scenario

The simulations are based on model version 3 of the COVID-19 model, which, as described in detail in the policy brief[1] dated 15.05.2020, consists of the 2 main components:

• a network-based epidemiological infection model (epidemic model) and

• a model for the course of the disease (disease model).

Model version 3 takes detailed subnetworks into account that were derived from IGSS data provided by the Luxembourgish social security administration and explicitly contains the social interaction networks that considers social interactions based on households, employment and school associations, as well as general social interactions. This data allows a realistic assessment of interactions and the associated infection chains as well as e.g. an age-dependent characterization of the subnetworks.



Version 3 also integrates the detailed sector-specific activities available from IGSS datasets, which are implemented by NACE codes[2].

1.1 Reference scenario

With this model and the underlying assumptions, the dynamics of the epidemic can be modelled for different scenarios. The **current deconfinement situation was assumed as an underlying reference scenario** and considers:

• Shops and sectors as currently open as described in the IGSS data

• Remaining companies open on July 1st (with 1/3 of the employees in the home office)

• Construction remains closed in August

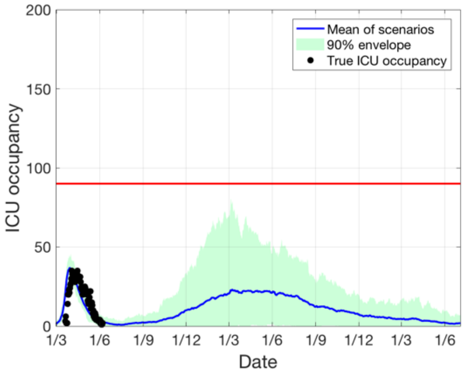
[1] https://storage.fnr.lu/index.php/s/UOZO8rQ9PJmzeEo/download
[2] NACE: Nomenclature des Activités Économiques dans la Communauté Européenne

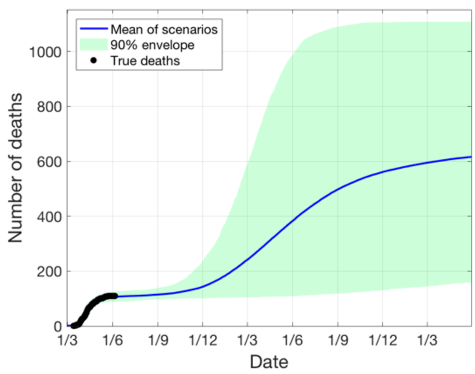
• Social interactions as currently decided and as described in the Policy Brief from May 15th

• General social distancing measures (masks, hygiene measures etc.) are followed.

To analyze the effect of the school operations, these have been explicitly excluded from the reference scenario and have subsequently been added to the different scenarios in Section 2.

With the above assumptions and the current virus prevalence, the simulations show a slight second wave that builds up over the fall and winter and has a maximum amplitude of 23 intensive care beds and would lead to just over 600 deaths. It should be noted that **the currently low number of cases leads to relatively high uncertainty in the forecasts**, which is illustrated by the green area of the 90% confidence interval.





Another source of uncertainty is the vacation period, for which travel behavior and the associated import cases are difficult to estimate. Despite this uncertainty, the underlying baseline can be used as a reference to analyze the effect of different school opening modes and additional deconfinement measures.

2. Simulations of school operations in the next school year

In order to analyze the effect of school operations on the epidemic, the different scenarios specified below were added to the reference scenario and compared with respect to ICU occupancy and number of deaths.

The simulations consider the state schools where according to IGSS data

• 34,270 primary school students (168 schools)

• 36,255 high school students (49 schools)

• 6,543 graduating students

are taught in 5799 classes with an average class size of 13.3 students.

The different scenarios of school operations are described below, with school operations with divided classes being compared to operations in complete classes for the various assumptions of social distancing, contact tracing and large-scale testing (respectively "mesh tracing").

These analyzes show that the **group size is crucial for the amplitude of the 2nd wave and that social distancing and contact tracing significantly reduce this amplitude**.

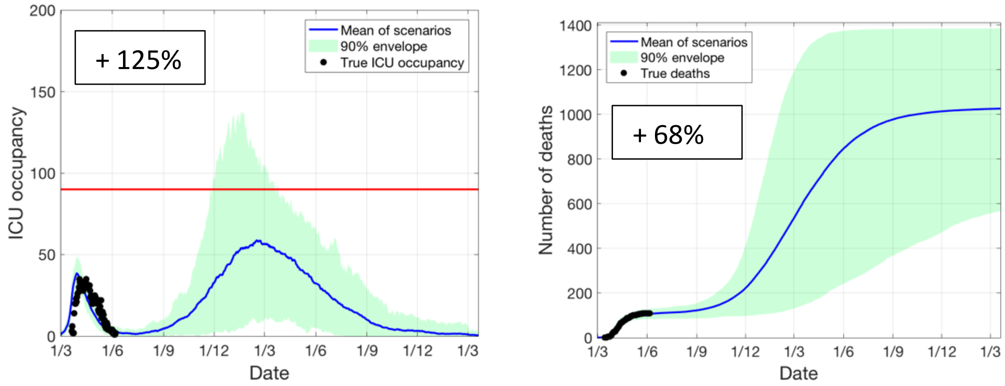
In particular, **the first simulations for Large-Scale Testing and corresponding "mesh testing"** (scenarios E and F), i.e. the continuous monitoring of the population and corresponding contact tracing, show that a second wave can be suppressed extremely efficiently as long as the population actively participates in these tests and a sufficient contact tracing capacity is available.

In the simulations for scenarios E and F, a test capacity of 95,000 tests / week was distributed to employment status and household membership in such a way that a group size of 6 is guaranteed in companies and a group size of 10 in households. To achieve this, smaller companies (with < 4 employees) and households have been grouped together, although they have no direct physical interactions. This leads to a reduced effective test frequency of 14 days in these subgroups. In the corresponding simulations, the social distance at work and in schools was assumed as in the previous scenarios.

Since contact tracking is essential for breaking the chains of infection, the **Large-Scale Testing should be supported by socially distancing** to avoid possible bottlenecks. This is described in a more systematic manner in Section 4 on Large-Scale Testing.

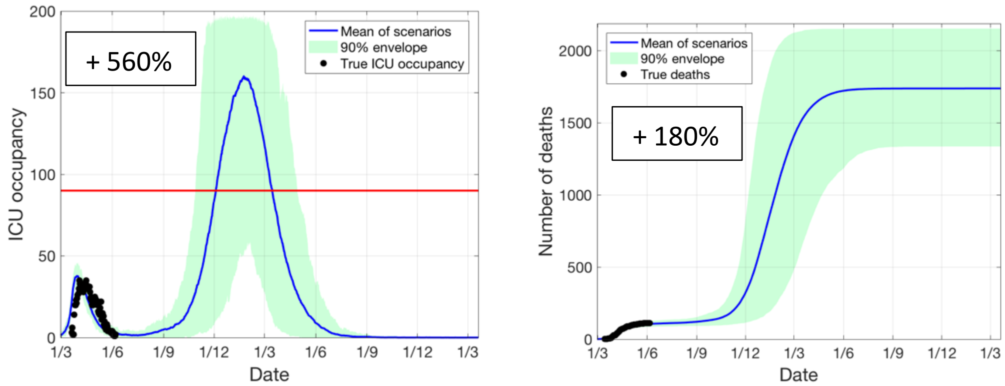
2.1 Effect of school operations in divided or undivided classes in the next school year

A. School operation in divided classes without social distancing and contact tracing



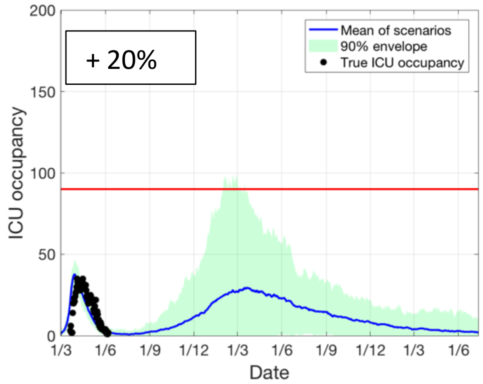
This results in an increase of 125% of the maximum required ICU capacity and a 68% increase in deaths compared to baseline without school openings.

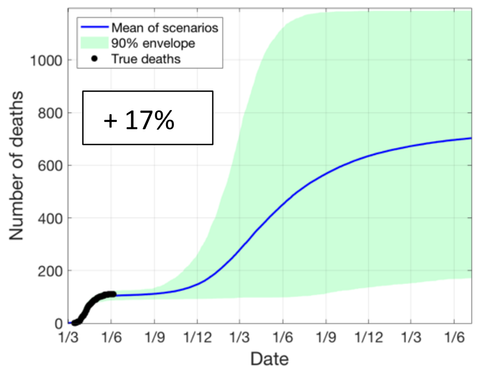
B. School operation in undivided classes without social distancing and contact tracing



This results in an increase of 560% of the maximum required ICU capacity and a 180% increase in deaths compared to baseline without school openings.

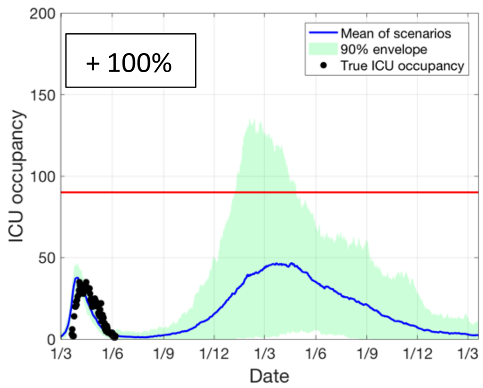
C. School operation in divided classes with social distancing and contact tracing (70% efficiency)

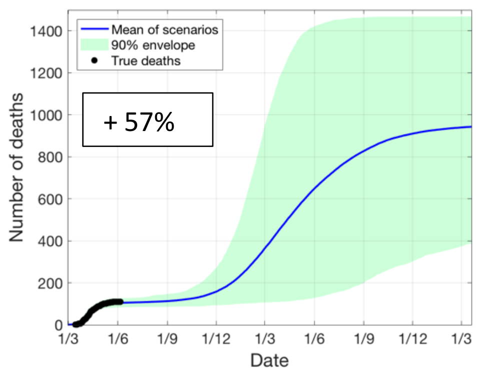




This results in an increase of 20% in the maximum required ICU capacity and a 17% increase in deaths compared to baseline without school openings.

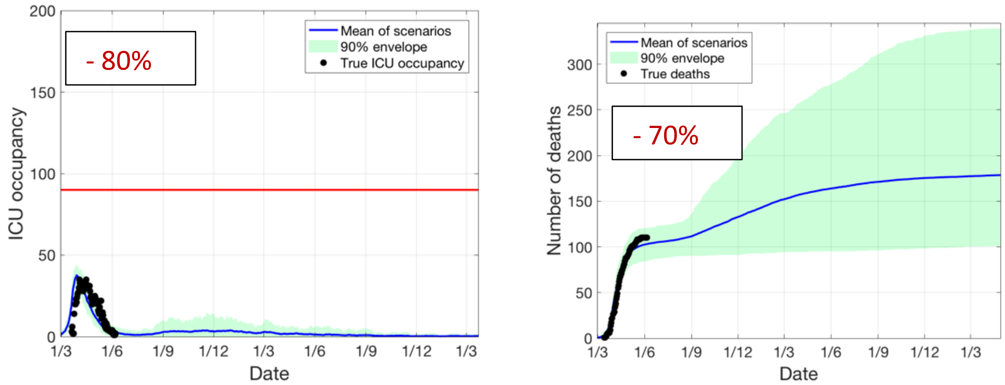
D. School operation in undivided classes with social distancing and contact tracing (70% efficiency)





This results in an increase of 100% of the maximum required ICU capacity and a 57% increase in deaths compared to baseline without school openings.

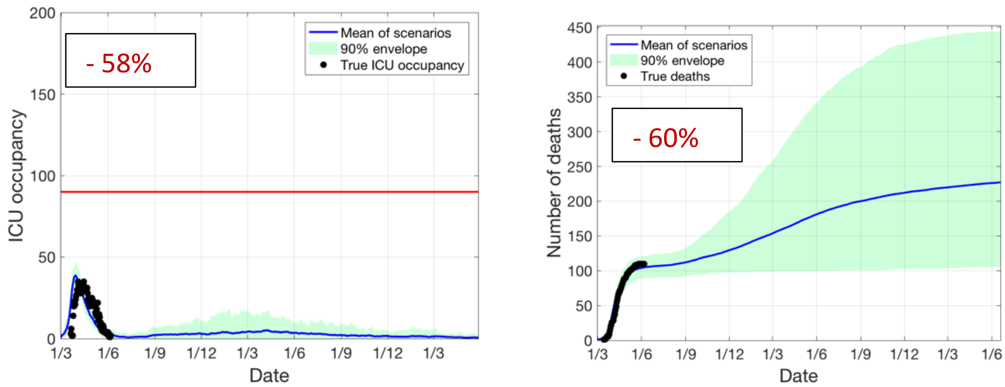
E. School operation in divided classes with social distancing, contact tracing (70% efficiency) as well as "mesh testing" (with 95,000 tests per week with which the population is monitored in interaction cells)



This results in a decrease of 80% of the maximum ICU capacity required and a 70% decrease in deaths compared to baseline scenario without school.

It should be pointed out that “mesh testing” was not included in the baseline and that there is therefore a significant reduction in the number of cases as long as sufficient contact tracing capacity can be guaranteed.

F. School operation in undivided classes with social distancing, contact tracing (70% efficiency) as well as "mesh testing" (with 95,000 tests per week with which the population is monitored in interaction cells)



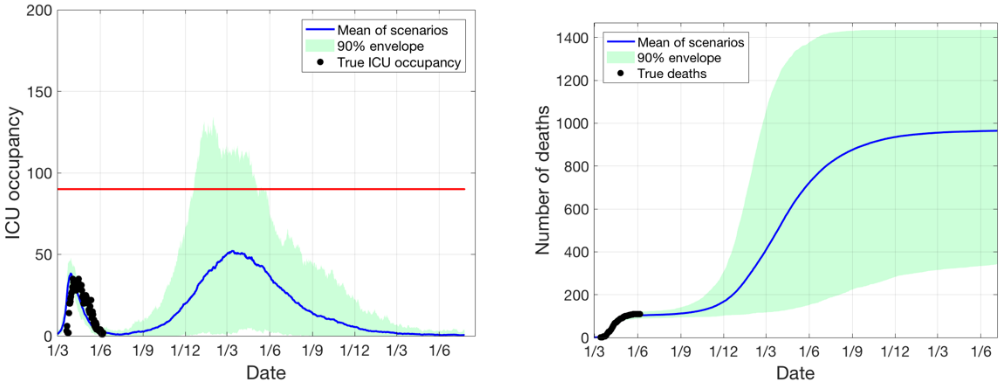
This results in a decrease of 58% of the maximum required ICU capacity and a 60% decrease in deaths compared to baseline without school openings.

It should also be pointed out here that “mesh testing” was not included in the baseline and that there is therefore a significant reduction in the number of cases as long as sufficient contact tracking capacity can be guaranteed.

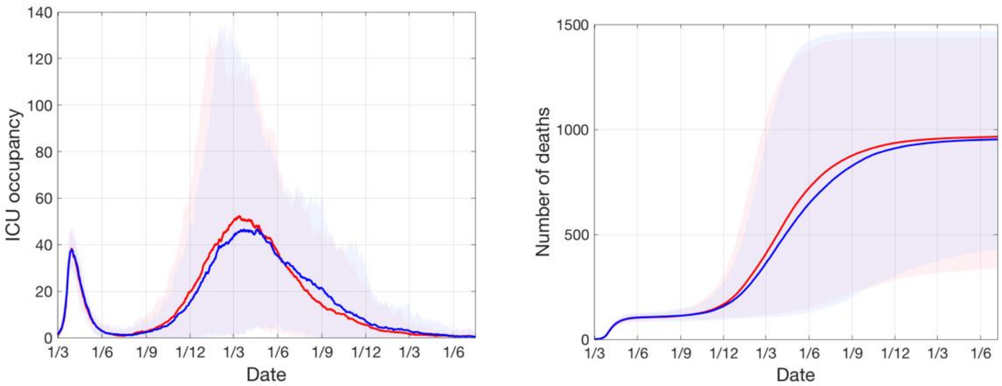
2.2 3. Simulations for joint lessons in the last two weeks of the current school year

In order to give a rough estimate of the extent to which teaching in the entire class group during the last two school weeks would have an impact on the course of the epidemic, this was simulated in comparison with scenario D above.

G. School operation in undivided classes with social distancing and contact tracing (70% efficiency) as in D but with undivided classes in the last two school weeks of the current school year.



This scenario shows no significant change from scenario D, in which the last two school weeks are still taught in separate classes. This becomes also evident from the direct comparison of the two scenarios:



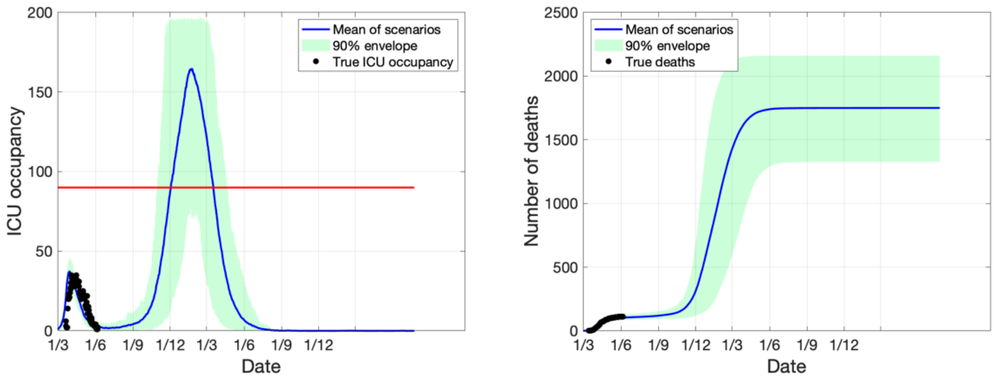
whereby scenario D (blue) and G (red) are almost identical given the uncertainties.

3. Effect of large private events

In order to estimate the effect of large private events, these were added to reference scenario (Section 1.1) **along with school operations in the entire class.** The events were parameterized based on family celebrations, such as weddings with the appropriate age distribution, and different sizes, i.e. **with either 50 or 200 guests,** and different frequencies of these events of **50 or 200 per week** in Luxembourg from July 1st.

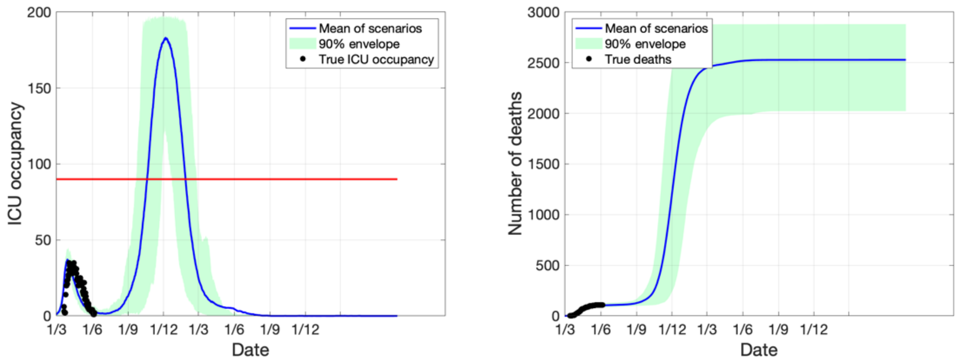
To include the effect of social distancing in school operations, the event scenarios specified below have been added to the above school scenarios with complete class associations.

H. School operation without social distancing and contact tracing (scenario B) and 50 events per week with 50 guests without social distancing



This scenario already shows an increase in the second wave compared to scenario B.

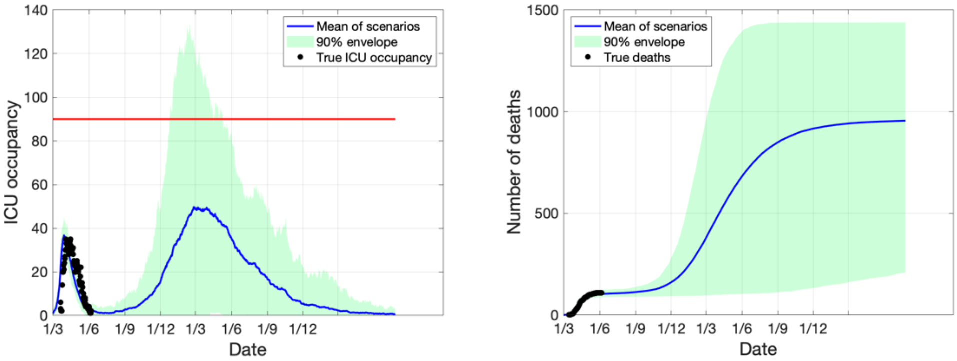
I. School operation without social distancing and contact tracing (scenario B) and 100 events per week with 200 guests without social distancing



This scenario shows a further increase in the 2nd wave compared to scenario B as well as a strong increase in the death toll compared to scenario H.

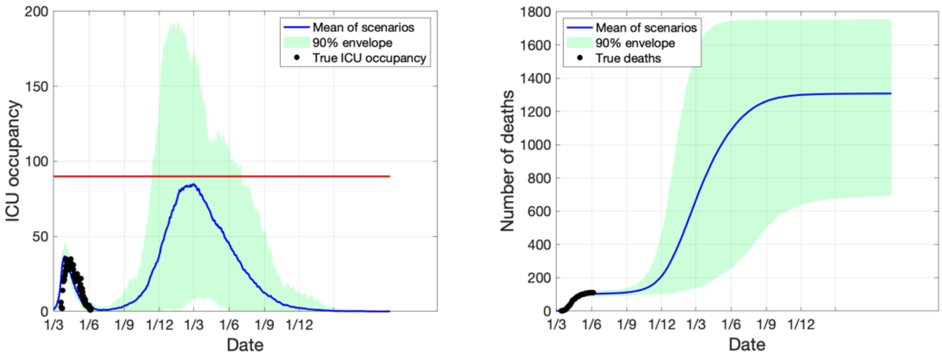
To further analyze the effect of social distancing, these scenarios H and I have now been simulated taking social distancing into account.

J. School operation with social distancing and 70% efficiency in contact tracing (scenario D) as well as 50 events per week with 50 guests with social distancing



This scenario shows again that social distancing and contact tracing significantly reduce the amplitude of the second wave (compared to scenario H) and that the ICU capacity is not exceeded.

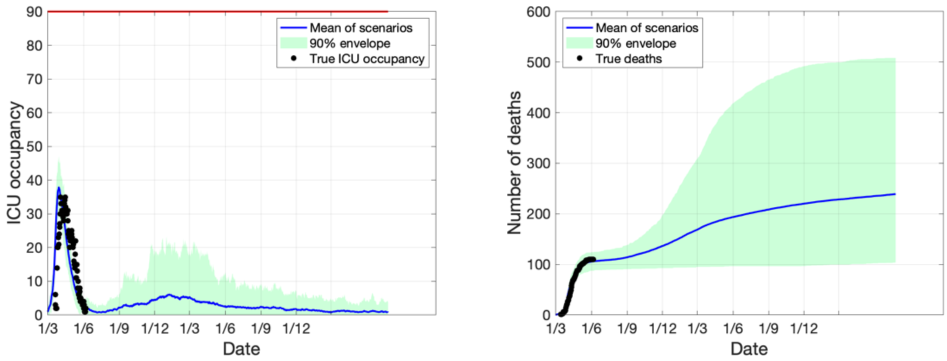
K. School operations with social distancing and 70% efficiency in contact tracing (scenario D) and 100 events per week with 200 guests with social distancing



This scenario also shows that social distancing and contact tracing significantly reduces the amplitude of the second wave (compared to scenario I), but the existing ICU capacity at 100 events per week can be exceeded with 200 guests.

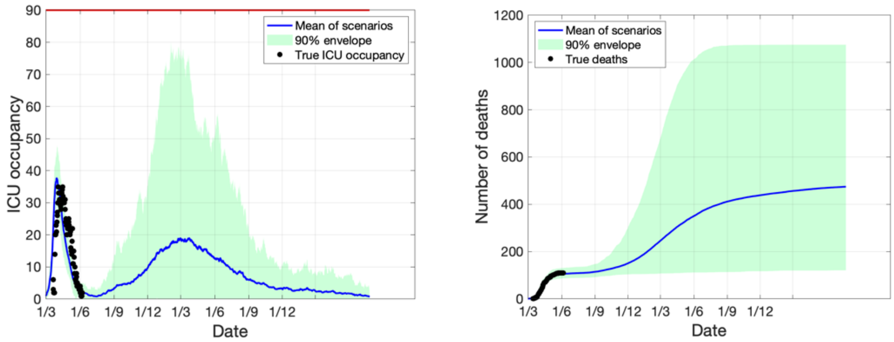
For a further analysis of the extent to which LST and the corresponding "mesh testing" of subgroups can influence the 2nd wave, the last two scenarios (J and K) were each expanded with a "mesh testing" as in scenarios E and F. For this purpose, 95,000 tests / week were assumed, which were distributed among employees and household memberships in such a way that a group size of 6 is guaranteed in companies and a group size of 10 in households.

L. School operation with social distancing and 70% efficiency in contact tracing as well as 50 events per week with 50 guests with social distancing (scenario J), which was expanded with "mesh testing" by 95k tests / week



This scenario again shows that the optimized “mesh testing” can have a significant effect on reducing the amplitude of the second wave and the number of deaths.

M. School operation with social distancing and 70% efficiency in contact tracing as well as 100 events per week with 200 guests with social distancing (scenario K), which was expanded with "mesh tests" by 95k tests / week



For this scenario, the corresponding mesh testing shows again a strong effect on the 2nd wave compared to scenario K, in a way that the existing ICU capacity is not reached.

It should be noted here that the optimized “mesh testing” of subgroups cannot completely compensate for missing social distancing and **the positive effect is essentially dependent on the capacity of contact tracing**. This is further elaborated in the next section 4 for the analysis of the LST.

4. The potential of Large-Scale Testing

As already shown in the simulations above, the large-scale testing can lead to a significant suppression of the 2nd wave, since infection chains can be identified and broken early on. This was analyzed in the simulations by modeling proactive monitoring of the population with 50k or 100k tests / week.

Furthermore, it was examined how these tests can be distributed as efficiently as possible, i.e. to what extent the definition of subgroups (also called cells or meshes) from which a representative individuum can be tested can be optimized in order to reduce the amplitude of the second wave.

For this analysis, the school operating scenarios (Section 2) were systematically expanded with various test strategies, whereby the LST and the corresponding subgroup testing were implemented from September 1st on from Monday to Saturday. In particular, subgroups were either defined:

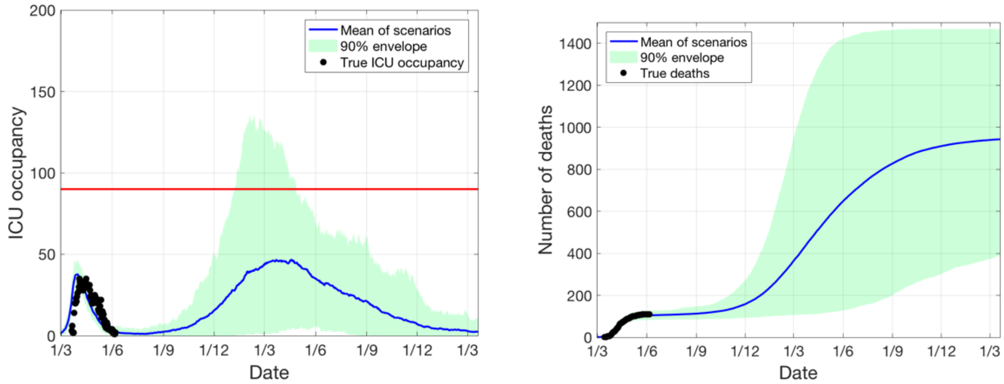
• randomly

• based on households or

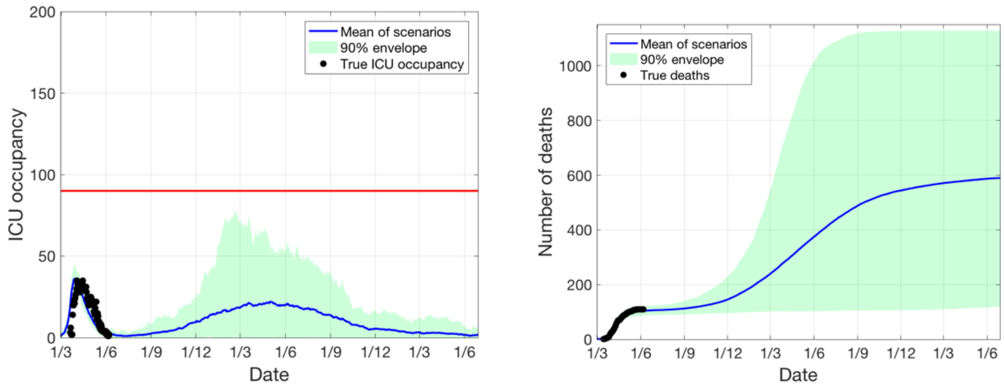
• based on working environment.

I. Comparison of LST with school operation in undivided classes with social distancing and contact tracing (scenario D)

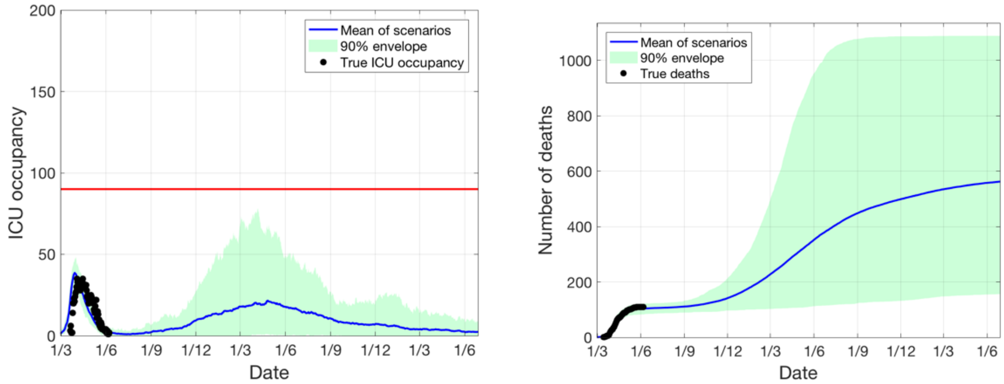
- **Without LST**



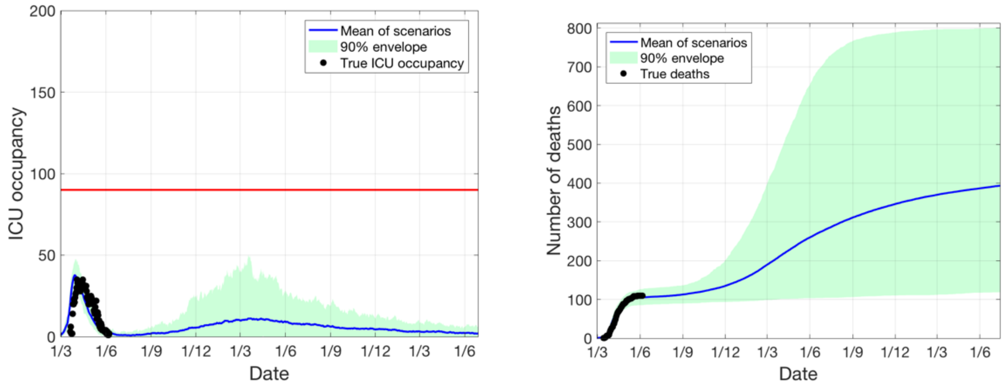
- **53k random tests**



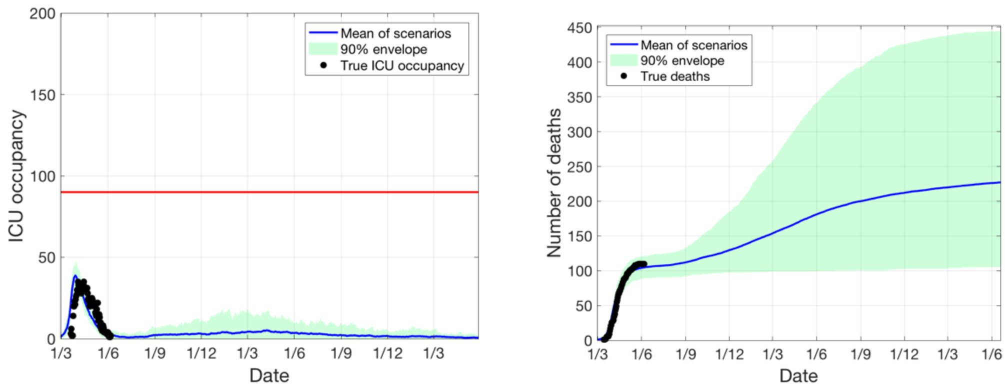
- **53k Tests / week on household-based subgroups**



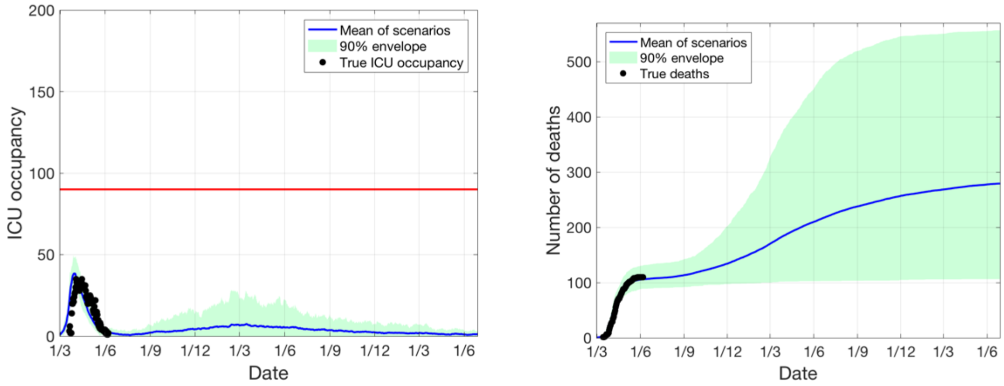
- **53k Tests / week based on workplace subgroups**



- **95k Tests / week based on mixed subgroup definition**



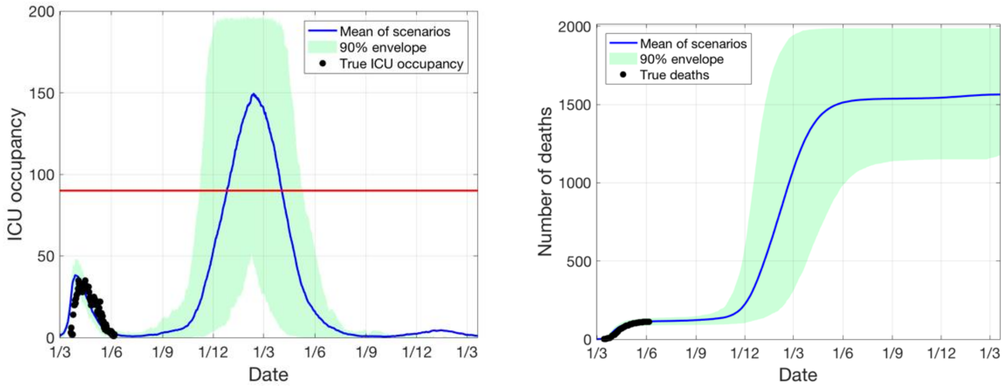
- **100,600 tests / week on household-based subgroups**



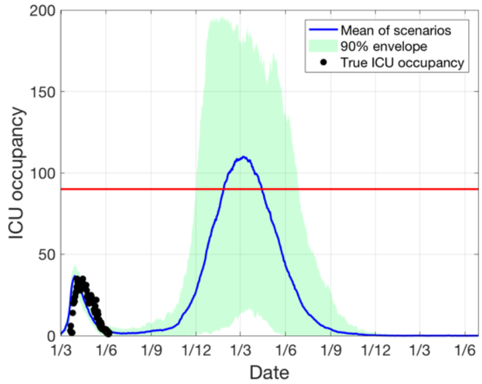
This analysis shows that **LST can significantly reduce the amplitude of the 2nd wave** and that **efficiency can be increased by clearly defined subgroups**. This is primarily due to the fact that a higher sampling rate (i.e. tests per group and week) can be guaranteed for the corresponding subgroup definition and thus potential hotspots can be recognized earlier and isolated by contact tracing.

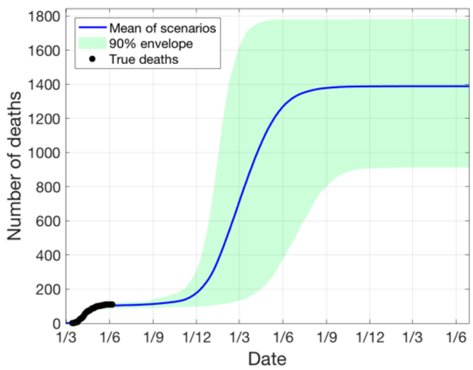
II. Comparison of LST in school operation in undivided classes without social distancing but with contact tracing

- **Without LST**

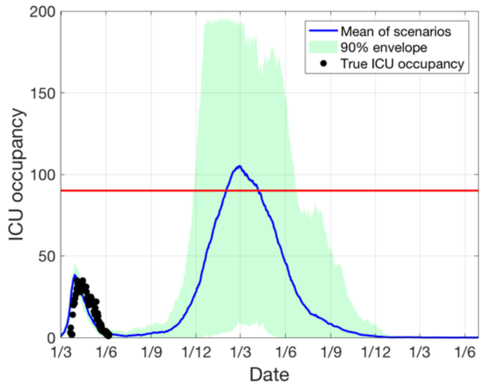


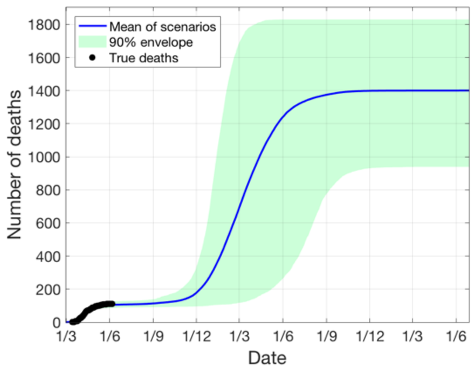
- **53k random tests**



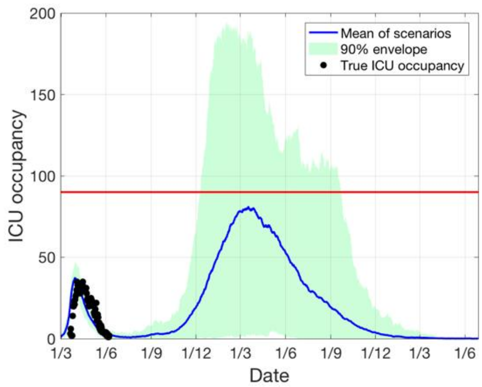


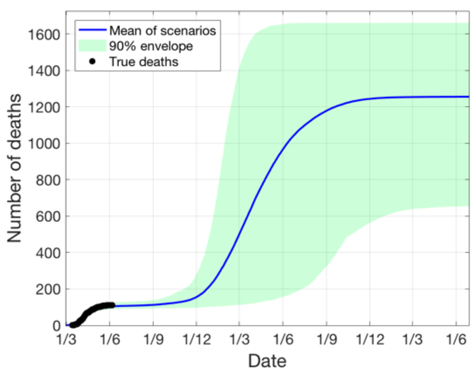
- **53k Tests / week on household-based subgroups**



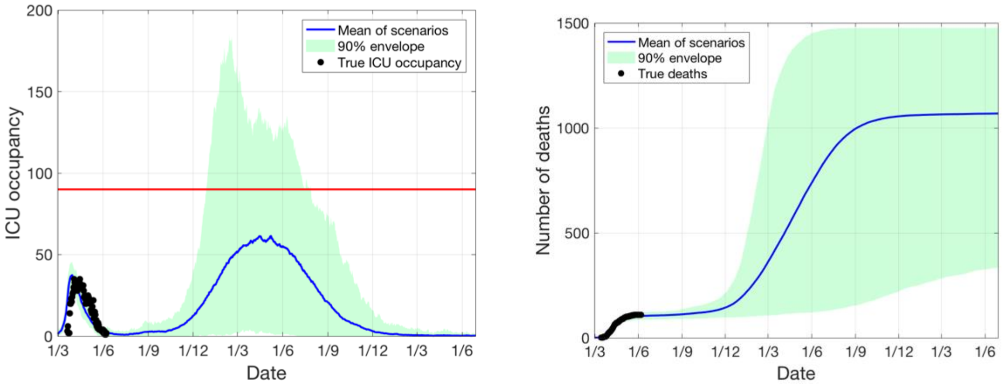


- **53k tests / week based on workplace subgroups**

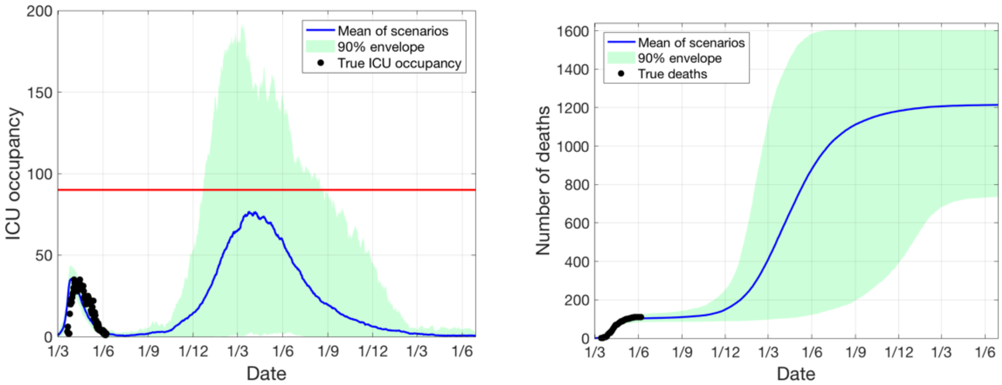




- **95k tests / week on mixed subgroups**



- **100,6k tests / week on household-based subgroups**

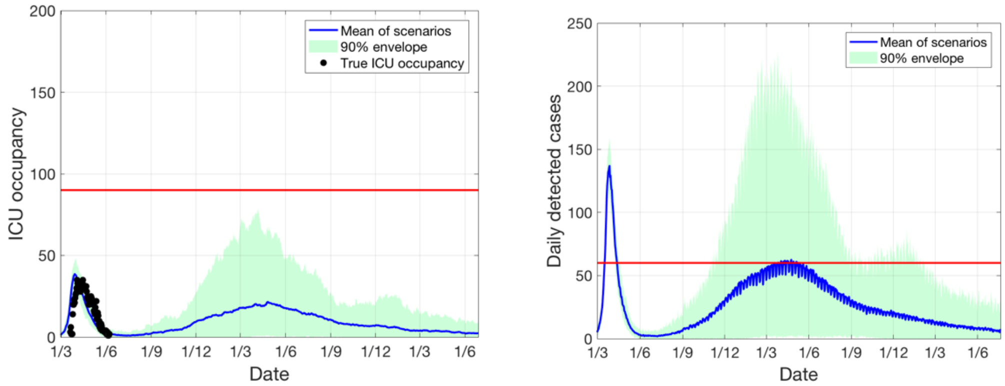


This analysis shows that in case of **lacking social distancing**, **LST still reduces the amplitude of the 2nd wave, but this is no longer effective enough** to be safely below the limited ICU capacity of 90 beds. This result is also relatively independent of the subgroup definition.

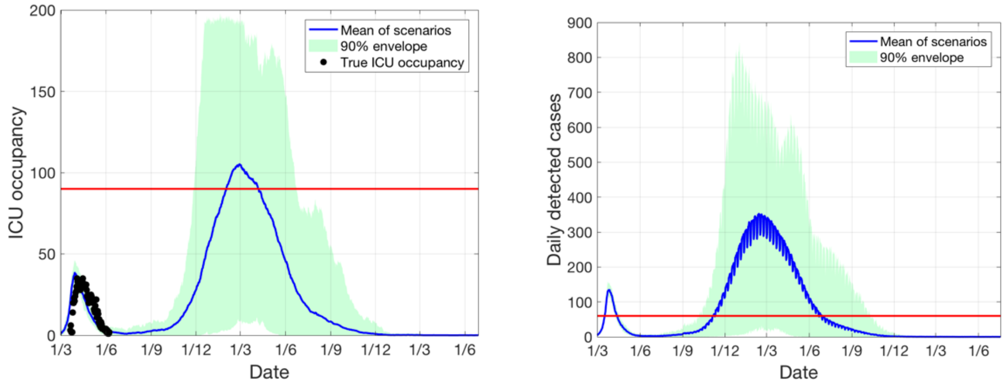
The further analysis shows that this is due to the increased number of identified cases per day, which exceeds the current upper limit of 60 cases per day of contact tracing and thus the infection chains can no longer be broken.

III. Comparison of identified cases by LST in school operation in undivided classes

- **With social distancing and 53k tests / week on household-based subgroups**



- **Without social distancing and 53k tests / week on household-based subgroups**



This first analysis shows how exceeding the detected positive cases beyond the contact tracing capacity limit of 60 cases per day leads to a sharp increase in the amplitude of the second wave. This means that **LST and subgroup testing should be supported by social distancing in order to ensure efficient contact tracing within the limits of the capacity and effective breakdown of the infection chains.**