Update on the current situation in Luxembourg

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This document provides an update of the report provided of October 16 on the second wave in COVID-19 infections in Luxembourg. To ease comparison, the recent developments are also commented on within the corresponding figure captions.

Analysis of the current situation

This document gives a short update on the analysis of the current epidemic status based on the data available up to October 22. Note that this analysis is mainly based on data of all cases and not of inhabitants only.
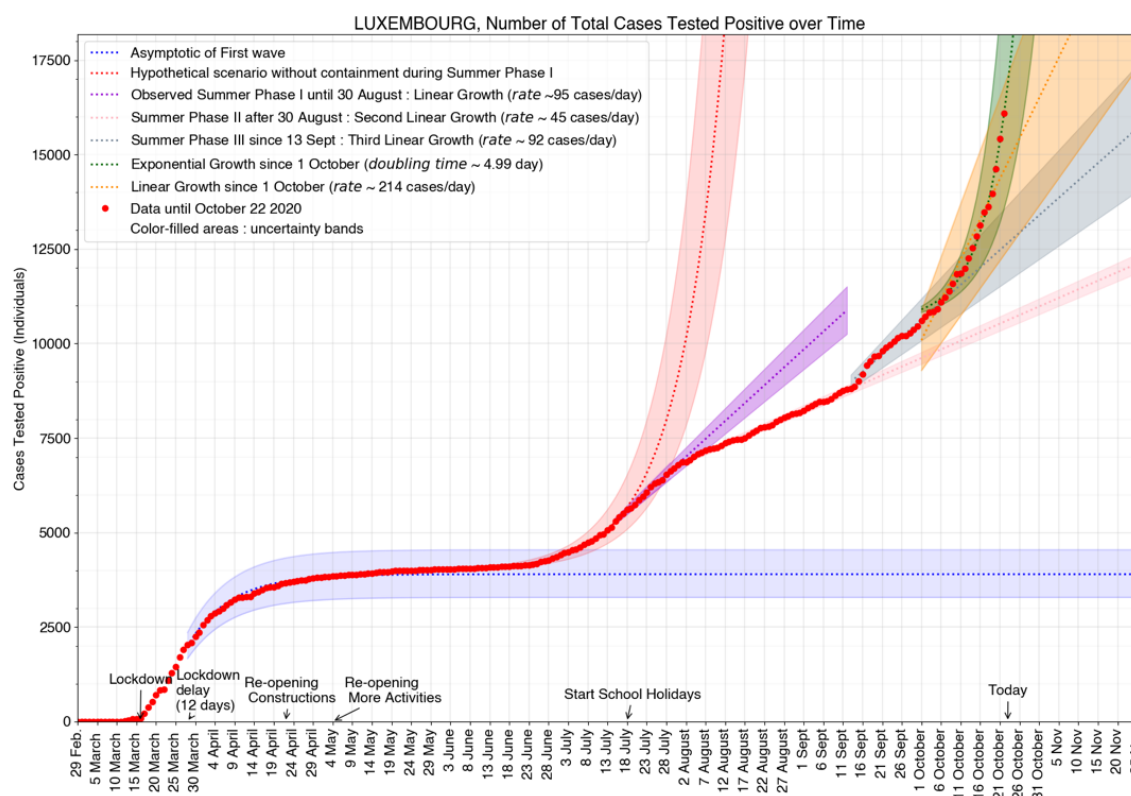
Overall, **the concerning regime of the exponential dynamics reported last week has further accelerated during the current week and the situation exhibits now an increasing exponential effect** as shown by

(i) an increase of R_{eff} to 1.61 (Figure 1) (compared to 1.31 last week) and a corresponding decrease in the doubling time to 4.1 days compared to 5.5 days last week (note that this is a continuous decrease in the doubling time over the last weeks),

(ii) the analysis of daily new cases and corresponding projections by curve fitting that exhibits now **an increasing exponential behavior** and a forced comparison of the non-linear regime exhibiting an increase to 214 cases/day compared to 157 cases/day last week (Figures 2 and 3),

(iii) the midterm projection by an epidemiological SIR model that projects now a 3 to 4 times increased amplitude of daily new cases for the next weeks compared to last week's projection (which has already doubled from the week before) with a maximum of around 1400 cases/day by mid of November (Figures 4),

(iv) a continuous increase in the overall positivity rate to above 5% for the current week compared to 2.5% last week (Figure 5),

(v) a nearly doubled number of estimated active cases of close to 5000 cases compared to last week (Figure 6).

This analysis indicates that the current epidemic situation is accelerating rapidly and appears highly volatile. In particular, the increasing exponential behavior and the high case numbers will put contact tracing beyond its limits and **mitigation of the epidemic wave can now only be achieved by a common social effort in reducing physical interactions, respecting hygiene measures and active participation in large-scale testing.** Without these efforts, the situation may culminate in a severe crisis in the healthcare system, especially if the recent trend of older people becoming infected now continues. The increased and more spread virus prevalence in the population will render the protection of these risk groups more challenging. Hence, it is now **essential that members of society respect the implemented measures and recommendations of physical distancing and hygiene measures to bring the epidemic in a controllable state again.** It remains to be seen how fast and effective today's implemented measures will support the slowing-down of the epidemic dynamics but it is to be expected that it will take up to a week or 10 days before the effect will manifest in the daily case numbers. The here presented analysis neither takes the new measures nor a potential change in people's behavior into account, both of which will hopefully have a beneficial impact on the epidemic dynamics.

Real-time effective R_t for LU
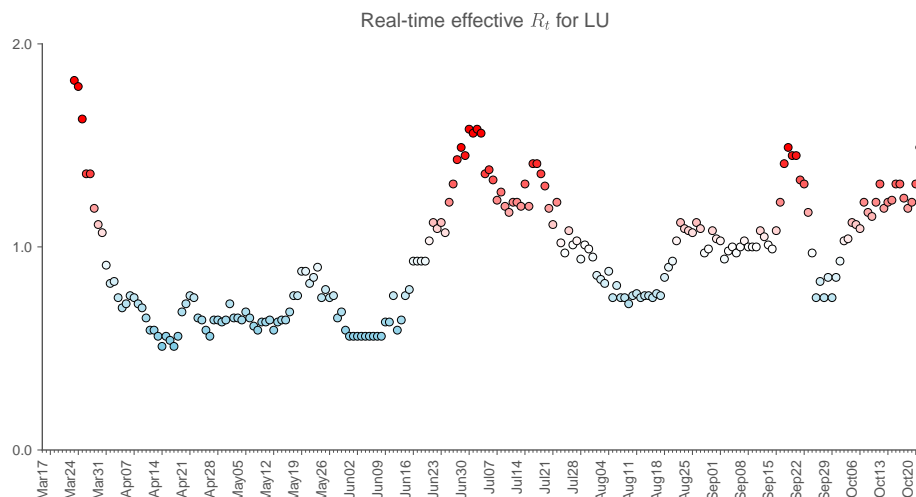
Figure 1. *During the current week, the effective reproduction number in Luxembourg increased from 1.31 to 1.61 (for inhabitants only) which corresponds now to a doubling time of 4.1 days (compared to 5.5 days last week). Note that this continuous trend and the strong increase during the last days indicate the severity of the current situation.*


LUXEMBOURG, Number of Total Cases Tested Positive over Time

Legend:
- Asymptotic of First wave
- Hypothetical scenario without containment during Summer Phase I
- Observed Summer Phase I until 30 August : Linear Growth (*rate ~95 cases/day*)
- Summer Phase II after 30 August : Second Linear Growth (*rate ~ 45 cases/day*)
- Summer Phase III since 13 Sept : Third Linear Growth (*rate ~ 92 cases/day*)
- Exponential Growth since 1 October (*doubling time ~ 4.99 day*)
- Linear Growth since 1 October (*rate ~ 214 cases/day*)
- Data until October 22 2020
- Color-filled areas : uncertainty bands

Figure 2. *Official COVID-19 case numbers up to October 22 (red dots) were approximated with an adapted model for short-term forecasts. The asymptotic behavior of the first wave is based on a multi-exponential model that describes the number of cases well until the beginning of May (blue). From 14 June on an initial exponential increase was observed as a potential second wave (red line). From mid to end of July the daily increase of cases showed an increase of 95 cases/days (summer phase I, magenta line) and from beginning of August to mid of September a linear increase of 45 cases/days (summer phase II, orange line). After the end of the vacation period mid of September, the situation seemed to have a similar behavior as the summer phase I with 91 cases/day (summer phase III, grey line) until beginning of October.* **The development during the last 3 weeks indicates a clear accelerated exponential behavior (green)** *and a forced linear fitting (orange) cannot describe the data well even with 214 cases/day.* *This relates to highly volatile* **exponential epidemic dynamics that can only be mitigated by common social efforts***.*

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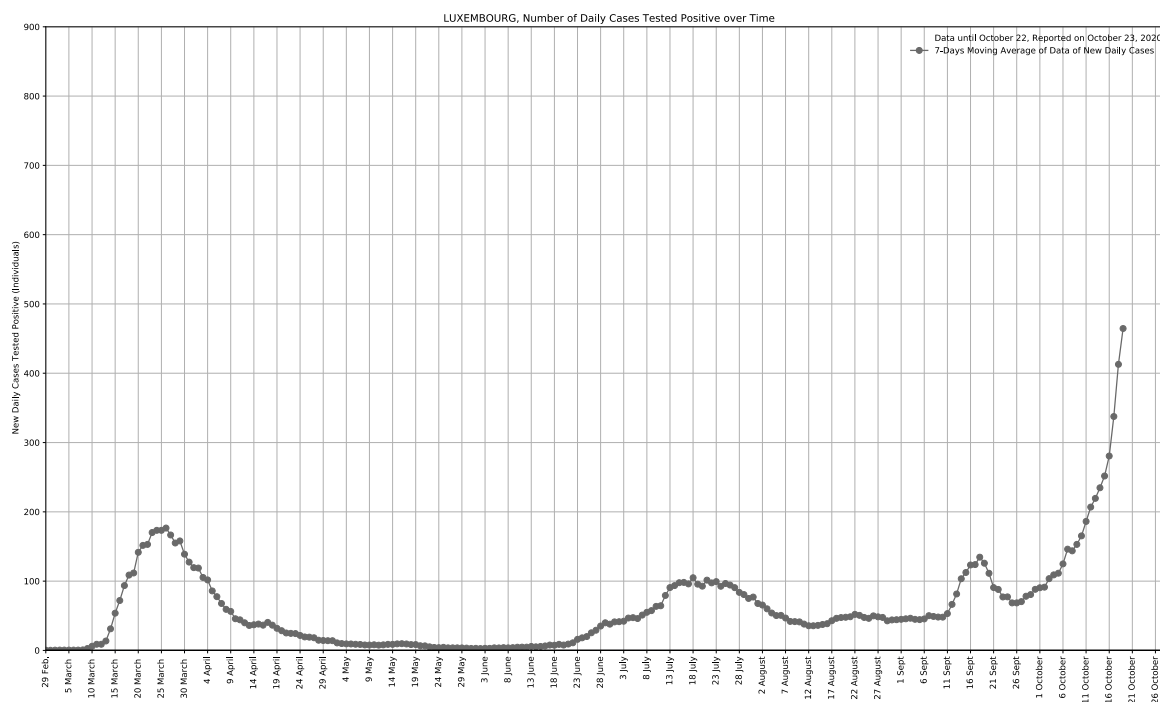
Figure 3. The daily COVID-19 case numbers up to October 22 (red dots) and the 7-day average (grey) exhibits an accelerated exponential growth since the beginning of October. Note that a linear regime is characterized by a flat curve such as during the vacation period with 45 cases/day and an exponential behavior would correspond to a straight line such as for end of September to beginning October. **During the last 2 weeks, the curve exhibits clearly a non-linear increase in daily cases which corresponds to accelerated exponential dynamics which is highly volatile**.

To estimate the midterm dynamics, we also applied an SIR model and parameterized it by a Kalman filter. The repeated strong increase in daily case numbers during this week leads now to the projection of a 3 to 4 times increased amplitude of around 1400 estimated daily cases of the second wave as shown by the comparison in Figure 4 between the estimates from last week (left) the current projection (right). The hopefully beneficial effect of new measures and a potential change in people's behavior on the epidemic dynamics is not included in these graphs.
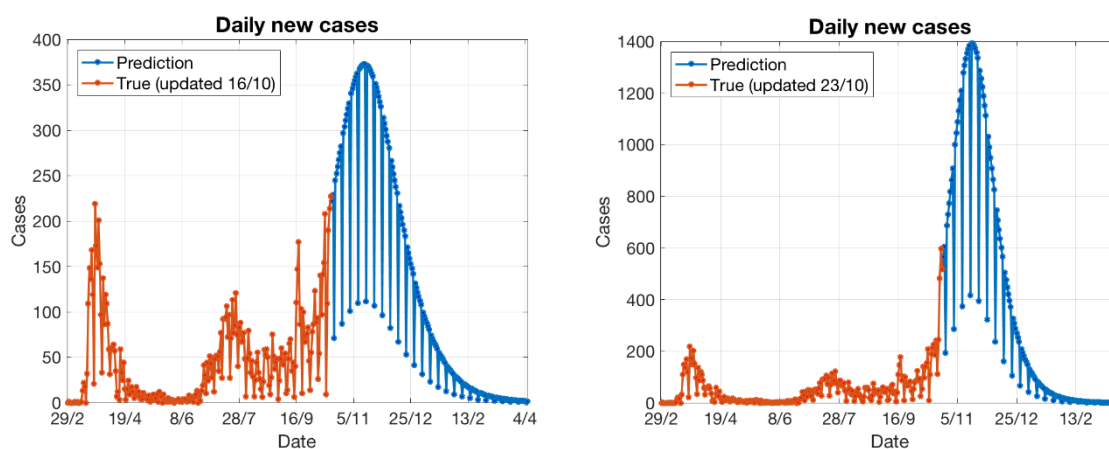

Figure 4. Comparison of midterm projections for daily cases from last week (left) and this week (right) based on an epidemiological SIR model parameterized by a Kalman filter. The comparison exhibits an earlier and 3 to 4 times higher peak of the second wave with around 1400 cases/day by mid of November. Note that in the projection the estimated dark number was adapted and the projection does not reflect the recently established measures and desired changes of people's behavior which hopefully contribute to pushing down the curve again.

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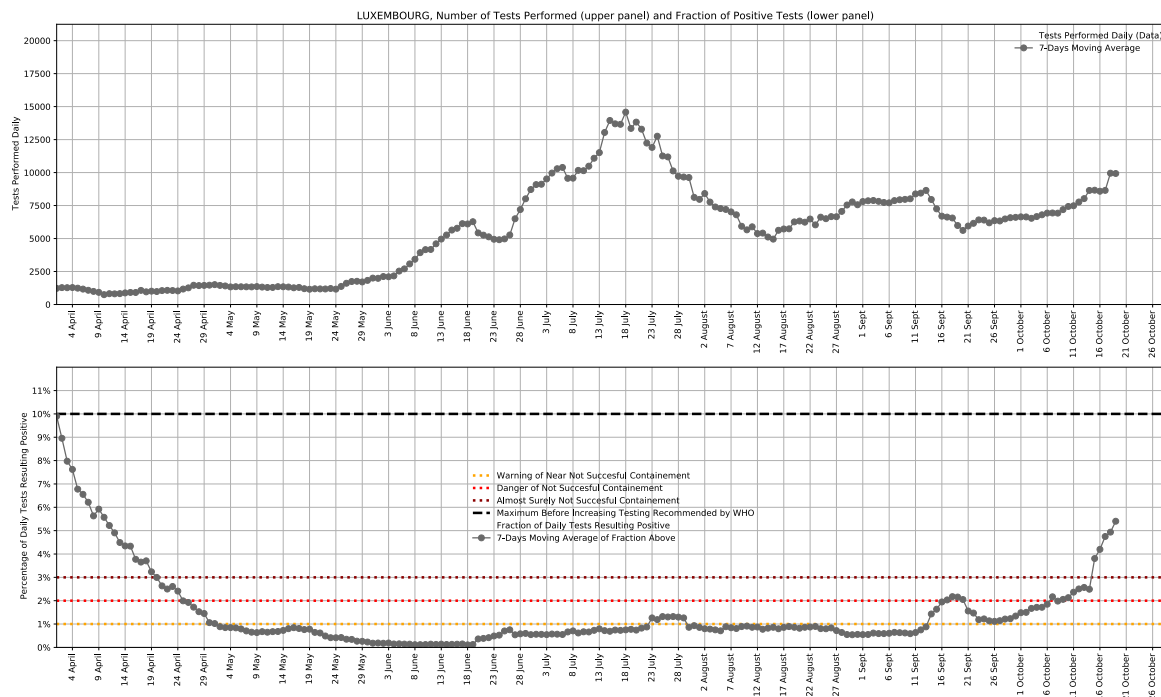
Figure 5. *The number of daily tests performed (top) and overall normalized positive tests (bottom). After the intermediate relaxation to around 1% end of September, the prevalence has continuously increased to approximately 2.5% at the end of last week and jumped to 5% during the current week. This dramatic increase further indicates the accelerated exponential dynamics.*
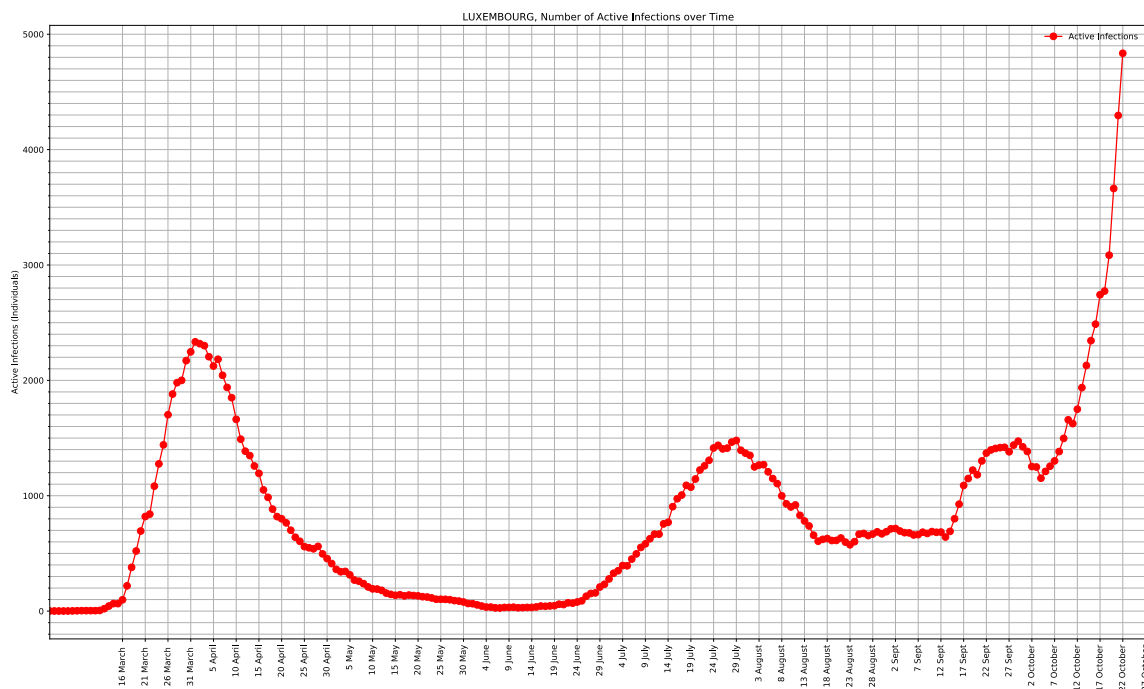
Figure 6. *After some stabilization end of September and a subsequent continuous increase during the following 2 weeks, the estimated number of active infections has doubled within the last week only with the new record value of nearly 5000 active infections.*
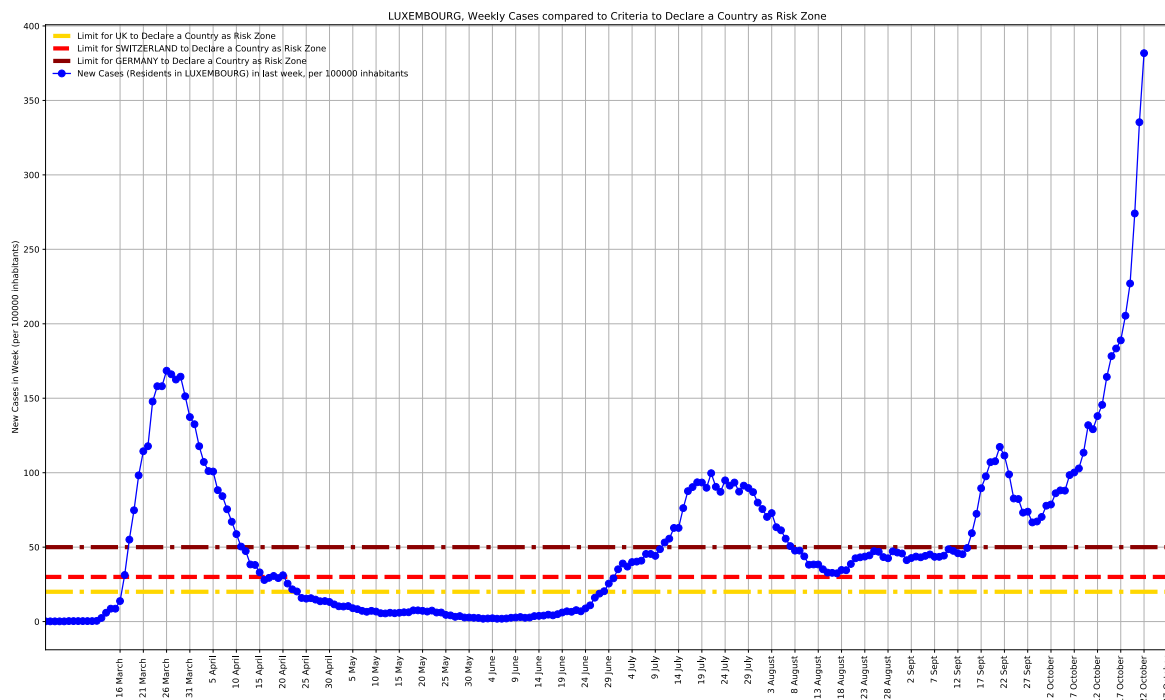
Figure 7. *The number of weekly cases per 100,000 inhabitant (blue line for inhabitants only) that is used by different countries to declare thresholds for risk zone definitions such as Germany with 50 cases per week and 100,000 inhabitants (dark red line). Luxembourg has surpassed this threshold since the week of 17 September and has reached the highest values since the beginning of the epidemic with a dramatic increase during this week.*