Covid-19 report: Update on the current epidemic status in Luxembourg

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Background information

This report has been elaborated by the Research Luxembourg Covid-19 Task Force to inform the Luxembourg Government about the current epidemic status in Luxembourg as an update to the last report from 9 December. It gives a short overview on the most important epidemic indicators and contains projections for the current epidemic status **based on data available up to 15 December**.

Main conclusions

- **The development during the current week exhibits a relaxation of the exponential epidemic dynamics with an indication for a switch towards a linear regime.** Thus, the 7-day average of daily cases for the current week has remained rather constant with 385 cases/day compared to 389 cases/day for last week. However, the appearance of the Omicron variant is likely to lead again to an exponential regime in near future.
- **R_{eff} of today has slightly increased to 1.05** compared to 0.98 on Thursday of last week, whereas the **7-day average value of R_{eff} has decreased to 0.98** compared to 1.06 of last week (Figure 1).
- The current week exhibits a linear trend and a corresponding fitting to the cumulative cases since November 16 indicates a slope 367 cases/day (Figure 2 and 3).
- The 7-day average for the **normal care hospitalization demands** has significantly increased (59 cases on average for this week compared to 50.6 cases for last week). **The average ICU occupancies** has again increased with 24.6 cases on average for this week compared to 19.7 cases for last week.
- Based on the recent relaxation of the epidemic dynamics, the current **midterm projections of daily cases** indicate a slightly more stable epidemic dynamics compared to last week's projections, with a rather stable average of daily cases of around 400 cases/day instead an anticipated peak of around 420 daily cases in January from last week's projections (Figure 4). The current pessimistic scenario also exhibits a reduction with a possible peak of around 600 cases in January compared to above 650 cases from last week's pessimistic scenario. However, these projections do not consider the Omicron variant which has the potential to lead to a doubling of daily cases compared to the current level within the next weeks. Note further that these projections do not consider future changes in social behavior or in more transmissible virus variants explicitly.
- The corresponding **projections of the hospital demands** exhibit also a stabilization for normal care at around 62 cases from the current projections compared to 70 cases in January cases from last week's projection (Figure 5). The projection for intensive care units also exhibit a stabilization on the current level of around 26 cases (Figure 6). For the more pessimistic scenario, these projections still indicate a potential peak of around 100 cases for normal care and 40 cases for ICU in January. Note that hospitalization and specifically ICU demands depend strongly on the age structure of the cases and the vaccination status of the population. Hence, it is particularly important that vulnerable people are vaccinated and remain cautious in their social interactions to prevent severe cases and an increase in hospital demands.
- The average **positivity rate** has further stabilized at around 9% (Figure 7).
- The total number of **estimated active cases** has slightly increased to 5965 cases for this week compared to 5662 cases for last week (Figure 8).

While the recent trend of the dynamics towards a linear regime indicates a relaxation of the epidemic regime, the presence of the Omicron variant with its increased transmissibility will very likely lead to an exponential regime again within the next weeks with the potential to more than double the current daily case numbers already in January or February. This increase will also strongly depend on social interactions and vaccine effectiveness. Hence, sustained efforts in social distancing, in following hygiene measures as well as vaccination uptake, including booster shots, will be essential to mitigate the anticipated epidemic rebound due to the Omicron variant. In this respect, continued monitoring of breakthrough infections, virus variants and assessing their transmissibility will be a key element for future mitigation of the pandemic during the up-coming weeks and months.

Graphical analysis of epidemic indicators

Below, the epidemic indicators are visualized and analyzed in more detail including the midterm projections for daily cases and hospitalization.
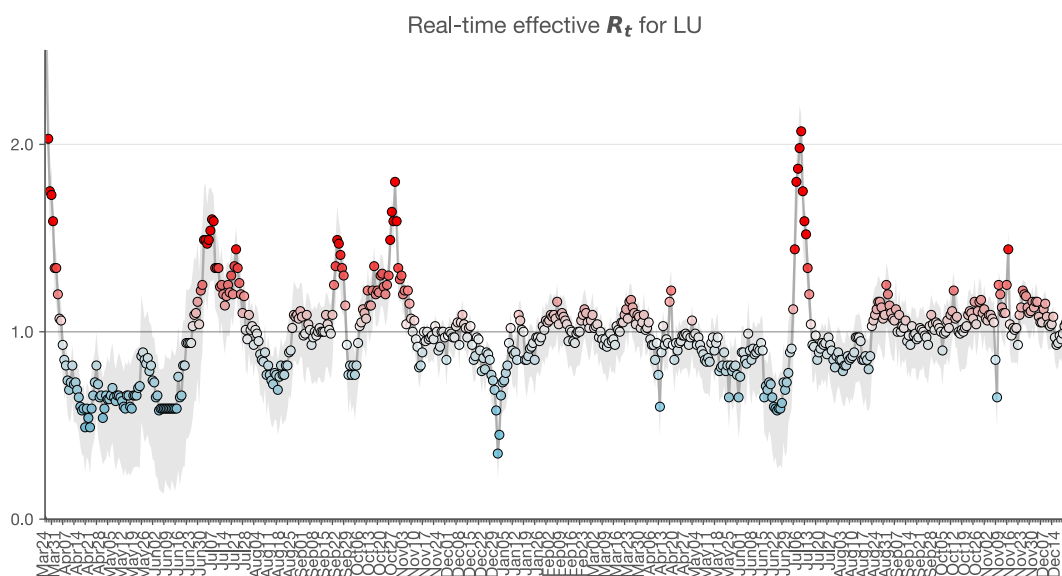

Figure 1. *For the current week, the effective reproduction R_{eff} has decreased to 1.05 today compared to 0.98 on Thursday of last week. The 7-day average of the current week has decreased to 0.98 compared to 1.06 of last week. Note that effective mitigation requires values below 0.8.*
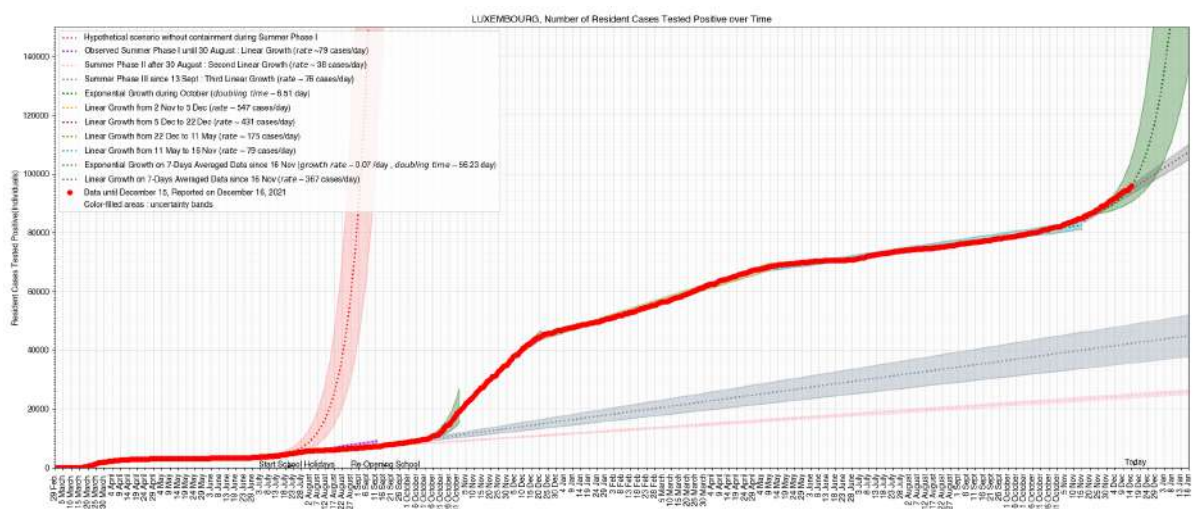

Figure 2. *Official COVID-19 case numbers up to 15 December (red dots) were approximated with an adapted model for short-term forecasts for the different phases of the epidemics (color coded). During the last month, the dynamics exhibited an exponential dynamics (green) with a trend towards a linear regime(grey) observed for the current week. **The recent relaxation indicates to a switch from the exponential behavior (green) to the linear dynamics (grey)**.*
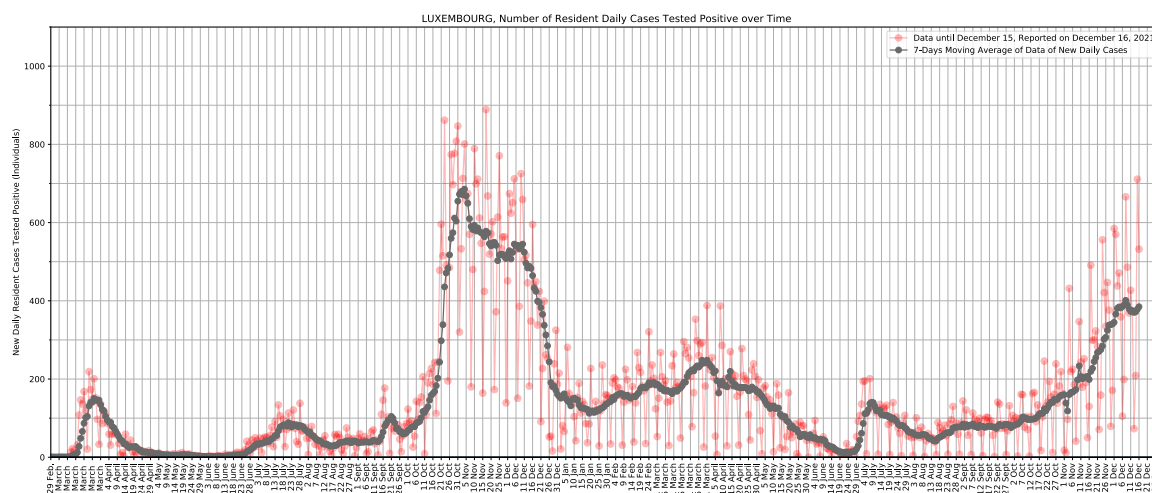
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Figure 3. The daily COVID-19 case numbers up to 15 December (red dots) and the 7-day average (grey). Note that a linear regime is characterized by a flat curve and that an exponential behavior would correspond to a straight line. **For the current week, the 7-day average of daily cases (grey) remained rather constant with an average of 385 cases/day for the last 7 days compared to 389 cases/day for the week before.** The constant behavior indicates the currently linear dynamics.

To assess the future epidemiological development in Luxembourg, we parameterized an extended epidemiological SIR model with data from Luxembourg by a Kalman filter. The model considers high and low risk groups, the current state of vaccination, and the vaccine efficacy against transmission for the delta variant inferred from Luxembourg data as 44% and 68% for the first and the second dose, respectively, and the efficacy against severe outcome as 74% and 85%, respectively. Based on these assumptions and the current age-distribution of infected persons of the last two weeks, the model integrates the dynamics of daily cases, hospitalizations and ICU occupancy and projects the future development of the epidemics. Note that the model does not consider future changes in social behavior or vaccine efficacies explicitly and that the projections are accompanied by uncertainties as shown by the confidence intervals, which currently correspond to a 10% decrease or increase in social interactions for the optimistic and pessimistic scenarios, respectively (Figures 4 to 6).

The midterm **projections of the 7-day average of daily new cases** (Figure 4) estimate the current level of social interactions and consider the vaccination status. The current projections reflect the stabilization of the epidemic dynamics in a linear regime. Thus, the current projection for **the 7-day average of daily cases** indicates a rather constant level of around 400 cases/day for the next weeks (Fig. 4 left) compared to a peak of around 420 cases/day in January based on last week's projection (Fig. 4 right). In the currently volatile epidemic regime, small changes in social interactions can have a significant impact as shown by the optimistic and pessimistic scenarios. In the pessimistic scenario, the current upper bound corresponds to a 10% increase in social interactions and shows that an epidemic rebound with a peak of around 600 daily cases could occur in January compared to the anticipated peak of nearly 650 cases/day from the projections of last week. This reduction in the current projections reflects the stabilization of the epidemic situation. However, the rather stabilized regime will be challenged by the more transmissible Omicron variant which may lead to more than a doubling of daily case numbers within the next weeks. Currently, the effect of the Omicron variant can be only roughly estimated given that the epidemic data from other countries cannot be directly adapted to the situation in Luxembourg. However the literature review indicates a significant higher epidemic potential probably based on breakthrough infections and higher transmissibility.
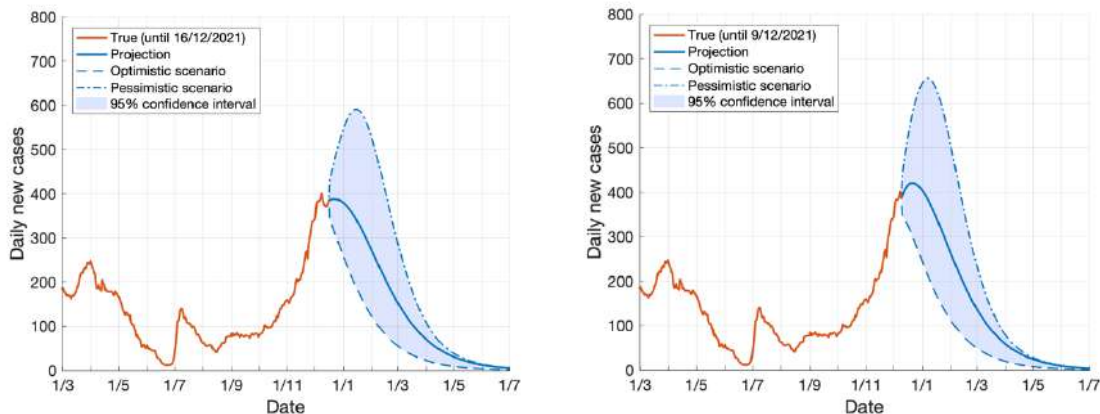
Figure 4. *Comparison of midterm projections for the 7-day average of daily cases from this week (left) and last week (right) based on an extended epidemiological SIR model parameterized to the situation in Luxembourg data by a Kalman filter. The blue solid line represents the most likely scenario whereas the optimistic (dashed line) and pessimistic scenarios (dashed-dotted line) correspond to a 10% decrease and increase in social interactions for this week's and last week's projections, respectively. **The comparison indicates a further stabilization in the epidemic dynamics where the shift towards a linear regime would lead to a rather constant level of around 400 cases/day during the next weeks (left) in contrast to an anticipated peak in January of around 420 cases/day in the projection from last week (right).** Note that the projection do not include the potential effect of the Omicron variant which may lead to more than a doubling in daily case numbers in the beginning of next year.*

The model **projection for normal care** also reflects the relaxation in the epidemic dynamics observed within the current week (Figure. 5) where the current projection (Figure. 5 left) indicates a decrease in the normal care demand at the current level of around 62 beds for the next weeks compared to a peak of around 70 beds in January from last week's projection (Figure. 5 right). This dynamic is based on the case numbers shown in Figure 4 and the current age distribution of cases. For the normal care demands, the volatile epidemic level bears also the potential for a significant increase in hospitalizations as shown by the pessimistic scenarios with a 10% increase in social interactions, which could lead to an increase in hospital demands of around 100 beds in January (Figure. 5 left). Note that hospitalizations depend strongly on the age distribution of cases since older people are more likely to develop severe symptoms and that changes in the age structure can induce changes in the projections accordingly. Furthermore, the projection does not include the anticipated effect of the Omicron variant which is likely to increase case numbers and hospitalizations.
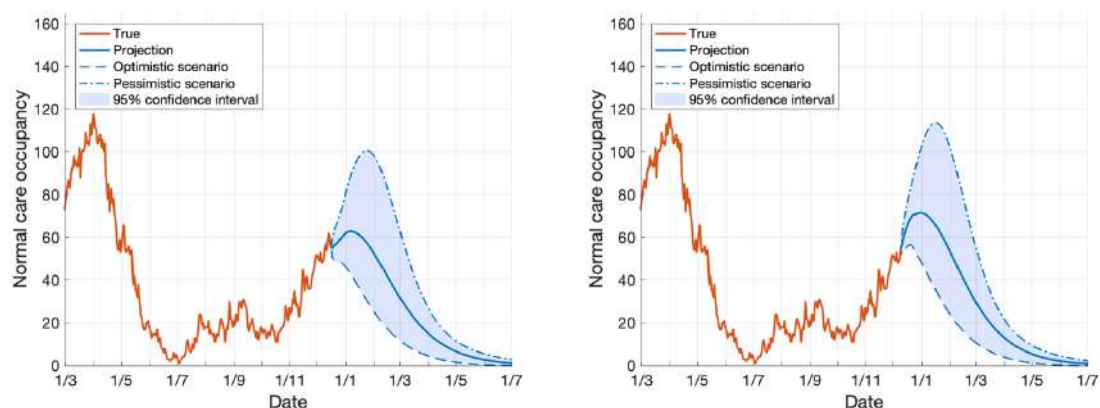

Figure 5. *Comparison of midterm projections for the 7-day average of normal care demands from this week (left) and last week (right) based on the extended epidemiological SIR model. The blue solid line represents the most likely scenario whereas the optimistic (dashed line) and pessimistic scenarios (dashed-dotted line) correspond to a 10% decrease and increase in social interactions, respectively for this week. **The comparison indicates a slight decrease in normal care demands to around 60 beds (left) compared to a peak of 70 beds in January in the projections from last week (right).** The volatile epidemic regime could lead to a significant increase in normal care demands as shown by the pessimistic scenario with a 10% increase in social interactions leading potentially to nearly 100 cases in January. Note that the projections do not consider potential effects of the Omicron variant.*

The corresponding **projection for ICU demands** also show a stabilizing behavior similar to the future development of case numbers and normal care demands. The current projection indicates a rather constant demand of 25 ICU beds for the next weeks (Figure. 6 left) compared to a peak of around 26 beds from the projection of last week (Figure. 6 right). The volatile epidemic level also bears the potential for a more significant increase in ICU demands as shown by the pessimistic scenario with a 10% increase in social interactions, which could lead to more than 40 ICU cases in January (compared to more than 43 beds from the estimate of the pessimistic scenario of last week's projection). Note that hospitalization and specifically ICU demands depend strongly on the age structure and vaccination status of cases. Hence, it is particularly important that vulnerable people are vaccinated and remain cautious in their social interactions to prevent severe cases. Note that these projections do not consider the potential effect of the Omicron variant.
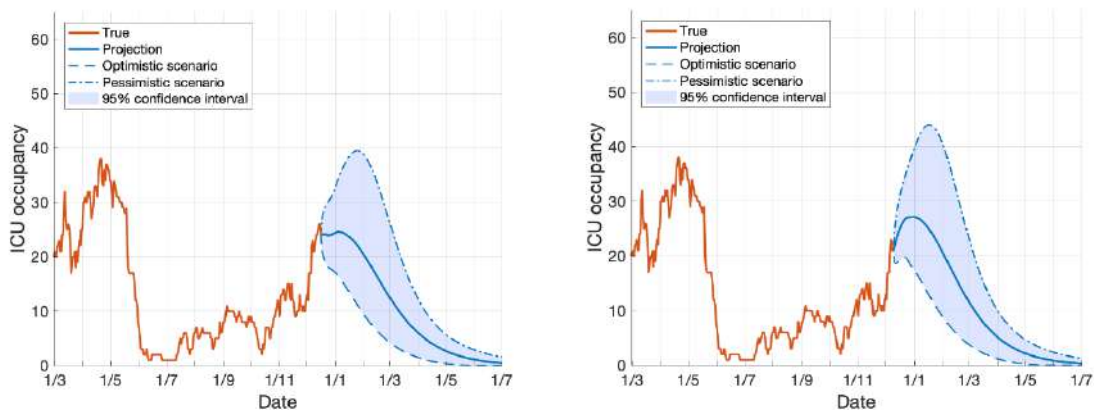

Figure 6. *Comparison of midterm projections for the 7-day average of ICU demands from this week (left) and last week (right) based on the extended epidemiological SIR model. The blue solid line represents the most likely scenario and the optimistic (dashed line) and pessimistic scenarios (dotted-dashed line) correspond to a 10% decrease and increase in social interactions, respectively for this week.* ***The comparison exhibits a rather constant ICU demand of around 25 ICU beds during the next weeks (left) compared to a peak of around 28 beds in January in last week's projections (right).*** *The current pessimistic scenario with a 10% increase in social interactions also shows a potential increase to around 43 ICU beds in January. Note that potential effects of the Omicron variant are not considered in the projections.*
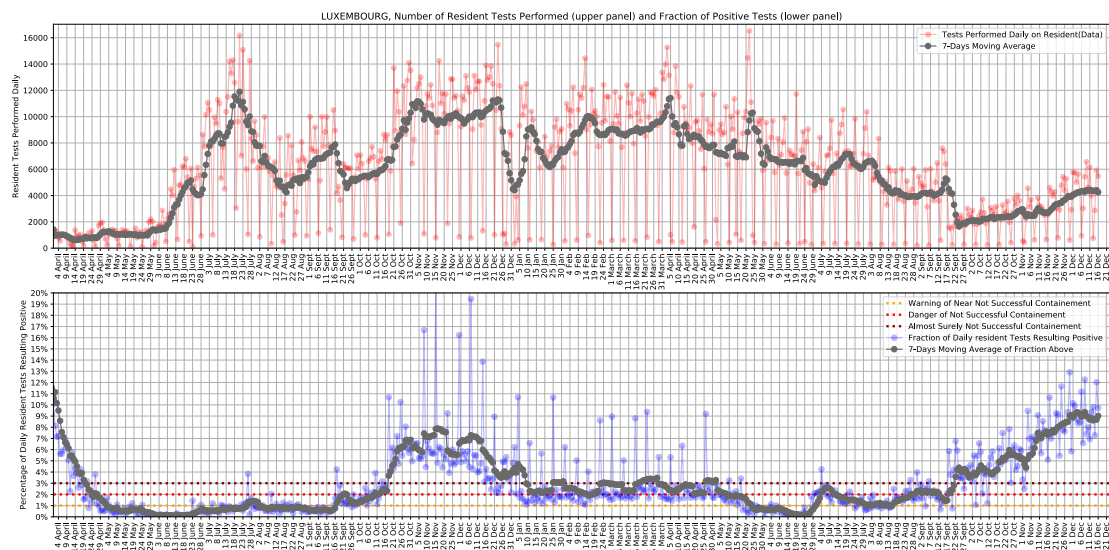

Figure 7. *Number of daily tests performed (top) and overall normalized positive tests (bottom).* ***During the current week, the 7-day average of the positivity rate (grey) has further stabilized at around 9%.***
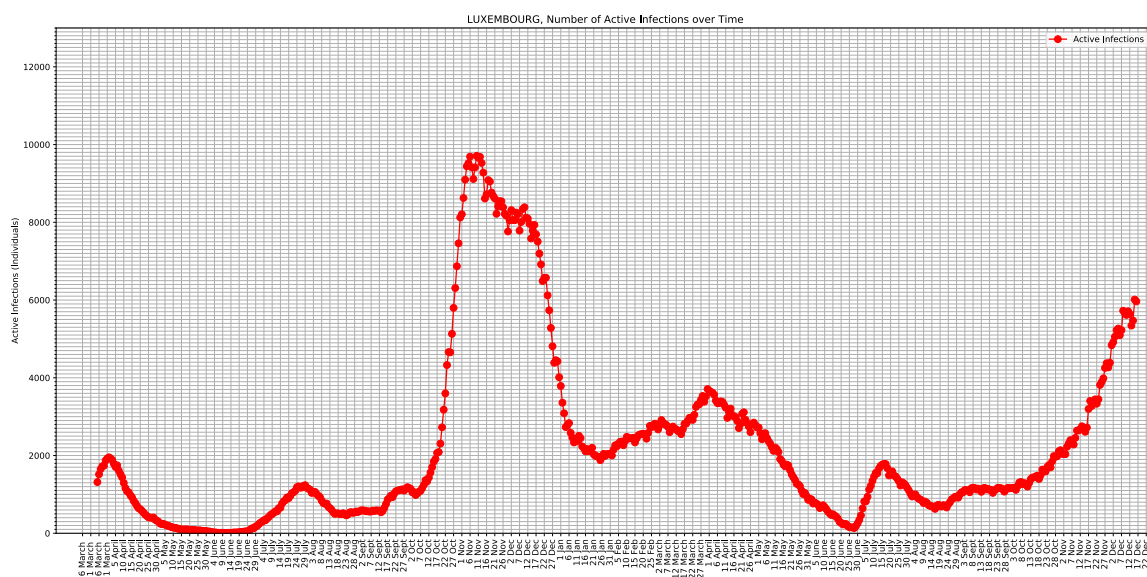
LUXEMBOURG, Number of Active Infections over Time

Figure 8. *During the current week,* **the number of estimated active cases has further increased to 5965 cases** *compared to 5662 cases for last week with some evidence for a saturation.*

LUXEMBOURG, Weekly Cases compared to Criteria to Declare a Country as Risk Zone
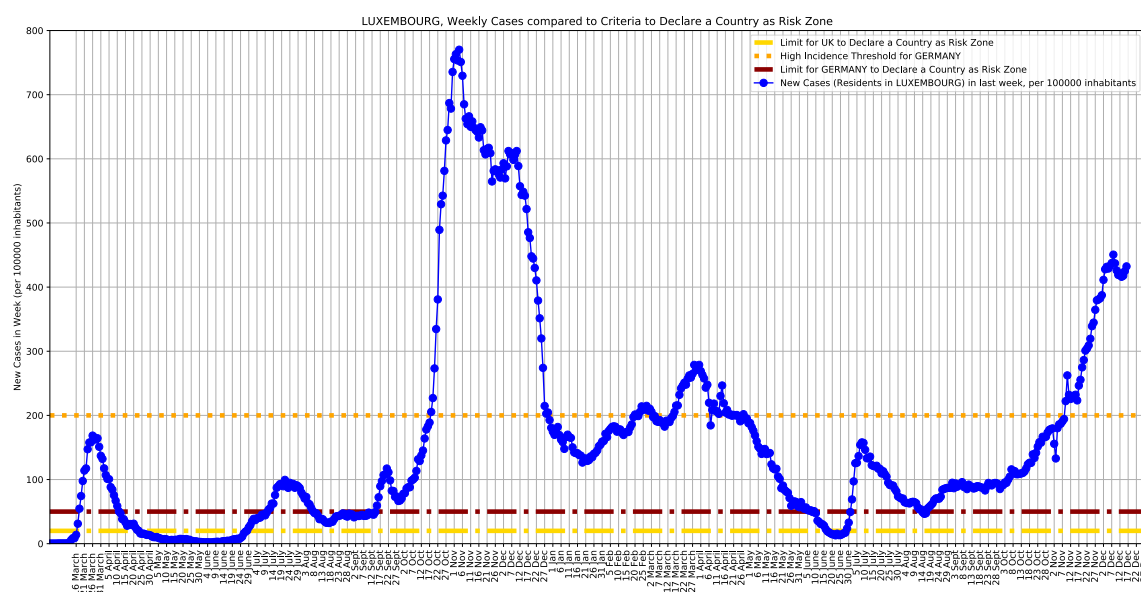
Figure 9. *Number of weekly cases per 100,000 inhabitants that is used by different countries to set thresholds for risk zone definitions such as Germany with 50 cases per week and per 100,000 inhabitants (dark red line).* **During the current week, the number of weekly cases per 100,000 inhabitants has stabilized at around 420 cases for this week compared to around 440 cases for last week.**