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K2P COVID-19 Series

Modeling COVID-19 Vaccine Rollout in Lebanon for Better Impact

Short Version

On February 21st, 2020 Lebanon recorded its first COVID-19 case. Since then, the country imposed five lockdowns in less than a year in an attempt to suppress the epidemic. The repeated closure and reopening episodes further worsened the economic situation in the country, decreased the public's trust in the national public health response to the epidemic, and were not successful in sustainably suppressing infection spread.

Why didn't the multiple lockdowns prevent epidemic surges?

To prevent epidemic expansion and a surge in cases, a key indicator, Rt, needs to be closely monitored to inform imposing and easing of restriction. The effective reproductive number, Rt, is the average number of secondary cases produced by one infected individual at any point in time throughout the epidemic. As long as Rt is smaller than 1, the epidemic will be declining. If Rt is greater than the threshold of 1, restrictions should be imposed; otherwise there will be resurgence. Restrictions should only be gradually lifted when Rt is less than 0.7, with continuous monitoring to ensure it remains below 1.

We plotted the trend in Rt in Lebanon over time since the end of June 2020 where SARS-CoV-2 epidemic expansion became noticeable to explore why the imposed lockdowns were not successful in sustainably suppressing the epidemic (Figure 1).

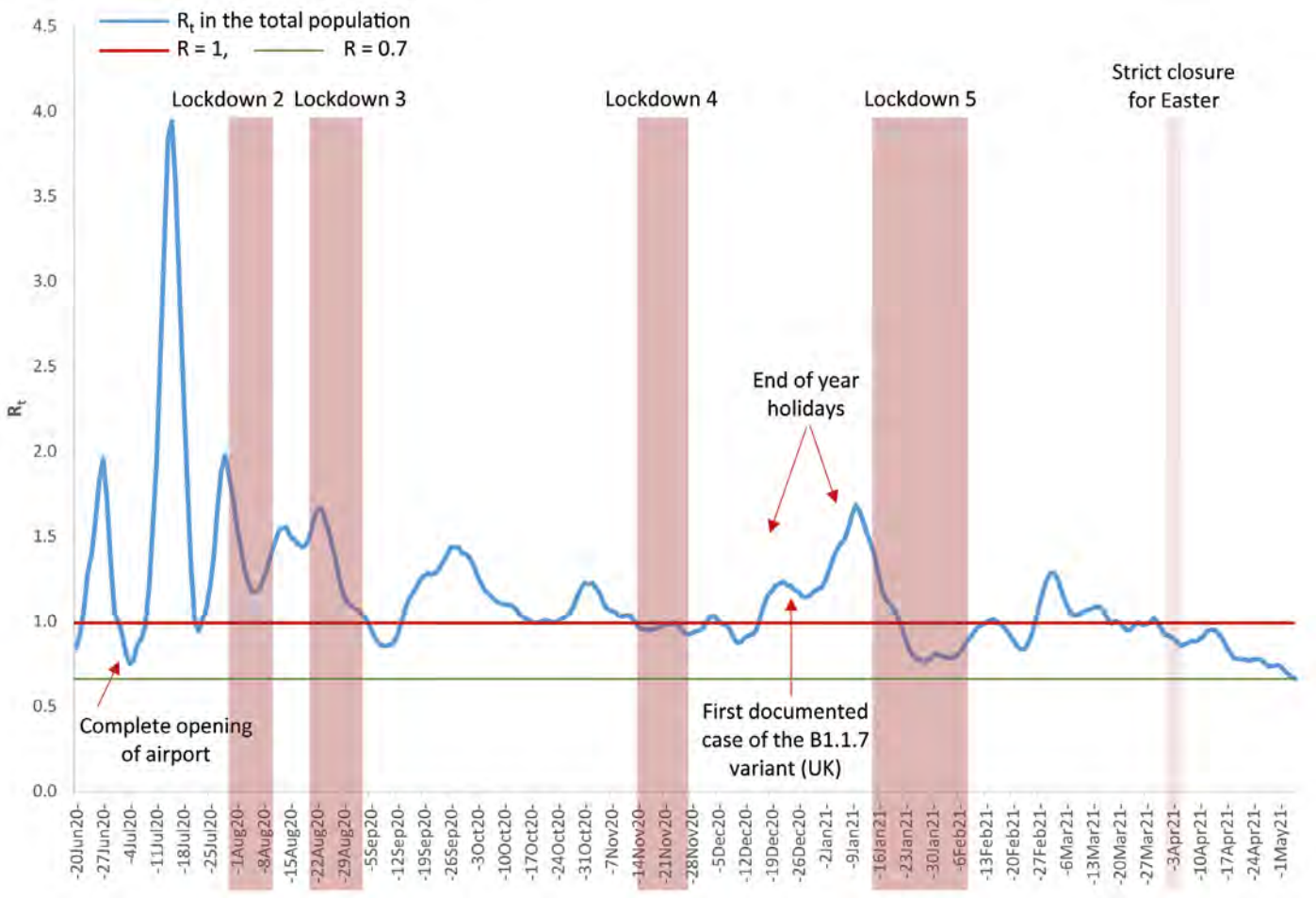


Figure 1. Trend in Rt in Lebanon, 20 June 2020-5 May 2021, and correlation with major events and response landmarks. Rt is estimated using the Robert Koch Institute method using case series data [10]. The graph highlights the two important thresholds: Rt of 0.7 which is the recommended threshold for when to start gradual easing restrictions (green line) and Rt of 1 which if crossed with easing too many restrictions will result in resurgence (red line).

A consistent observation is that all lockdowns were prematurely lifted when Rt was above the recommended threshold of 0.7, which did not allow any buffer for the increase in spread following the easing of restrictions and explains the quick surges that were subsequently observed.

What should we do to prevent new epidemic surges?

- Continuously, frequently, and closely monitor Rt (weekly estimations recommended).
- Only start lifting restrictions when Rt is less than 0.7.
- Stop lifting further restrictions if Rt approaches the threshold of 1.
- Impose restrictions as soon as Rt crosses the threshold of 1.
- Lockdowns are not always necessary - The level of restrictions imposed will depend on the value of Rt and on the overall epidemic situation.

Current situation: On May 5, 2021, Rt is estimated at 0.7, which reflects the marked recent decline in the number of confirmed cases. While immunity build up in the community is helping curb infection spread, caution should be taken because we are still far from population immunity levels that would prevent resurgence with full return to normalcy (estimated to be at least 80% for the new SARS-CoV-2 variants of concern). Hence the following are currently recommended:

- Scale-up vaccination and speed up their rollout to increase the level of immunity in the community which will alleviate the need for additional, stricter, and lengthier social distancing restrictions.
- If Rt remains consistently below 0.7 for at least one week, gradual easing of restrictions could be started
- During the process, monitor closely Rt to guide policy and inform decisions to lift or impose restrictions.

What is the predicted impact of vaccination on COVID-19 epidemic course in Lebanon?

With the expected relaxation of social distancing restrictions in the upcoming summer months and with the threat of the potential introduction of more transmissible and likely more severe SARS-CoV-2 variants, we conducted mathematical modeling analyses to forecast the short term (by end of year) impact of COVID-19 vaccination in Lebanon.

We simulated what would be the epidemic course if all restrictions are gradually eased over four months starting April 15, 2021, and if SARS-CoV-2 variants of concern are introduced, for the following three scenarios (figure 2):

- **Scenario 1:** No vaccination
- **Scenario 2:** vaccination started on February 14, 2021, and will gradually reach 80% coverage by the end of 2021 (Target coverage)
- **Scenario 3:** vaccination started on February 14, 2021, and will gradually reach 40% coverage by the end of 2021 (A more realistic scenario given the current vaccination roll out)

Vaccine Coverage is defined as the proportion of the population that had received the vaccine at a given point in time, regardless of their immunity status (they could already have natural immunity or they could be vaccinated but not immune because the vaccine is not 100% effective). Vaccine coverage is therefore a programmatic definition and, while they strongly overlap, is different than population immunity

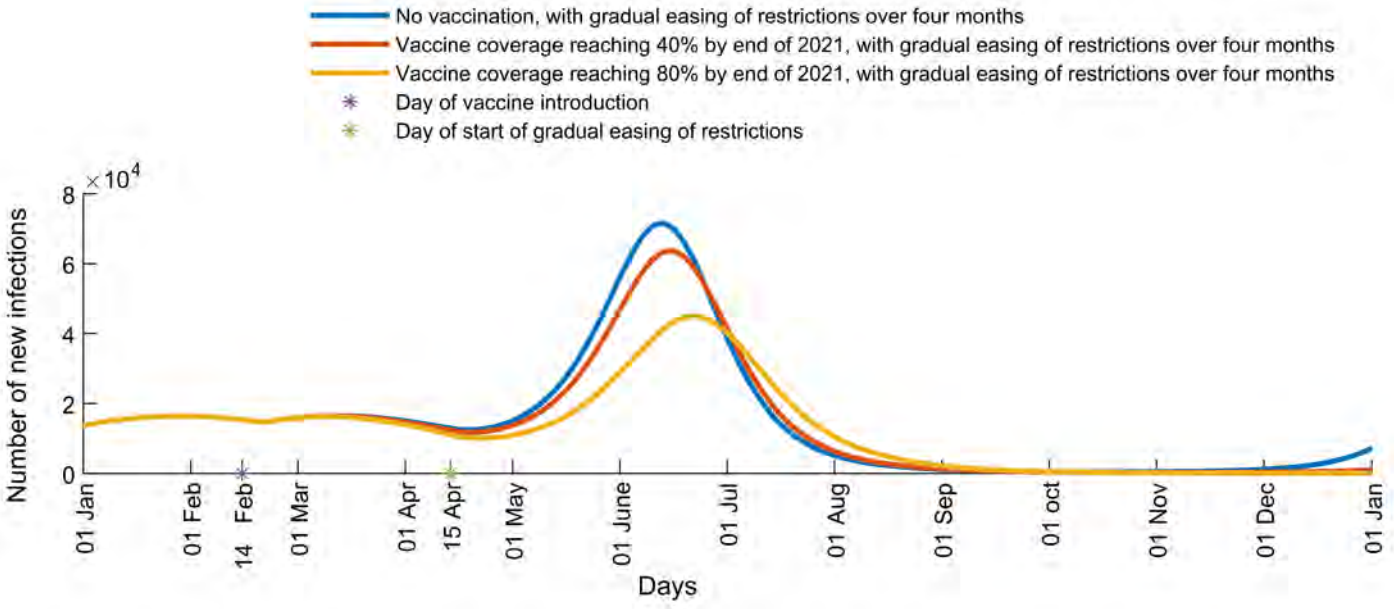
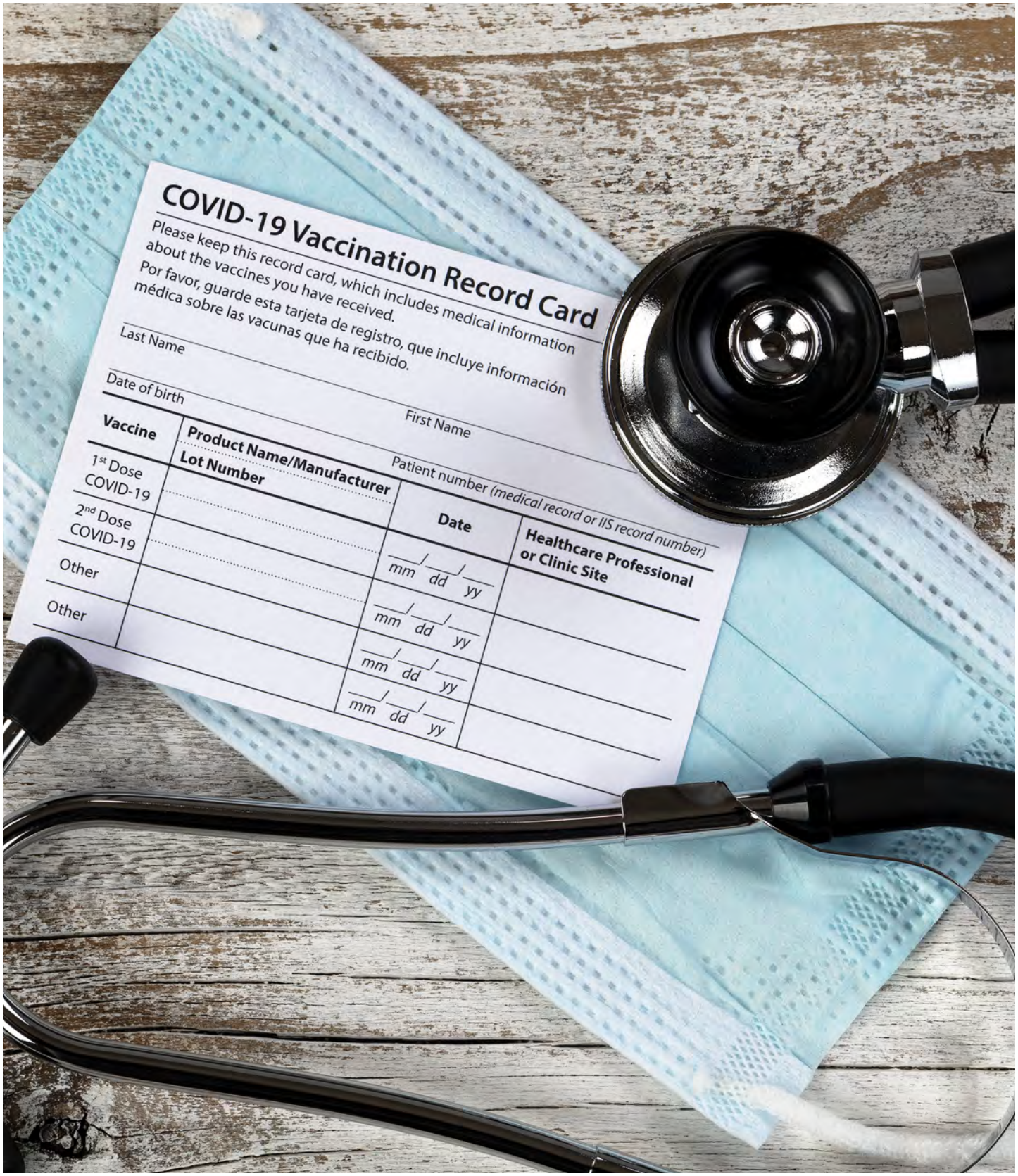


Figure 2. Impact of SARS-CoV-2 vaccination on the daily number of new infections* assuming gradual easing of all restrictions starting April 15, 2021.

* Of note that these are the estimated "true" infections, which include not only diagnosed/confirmed cases but also undocumented cases (asymptomatic/mild infections and any infections that did not present for testing).

- The model estimated that on April 15, 2021, around 40% of the population in Lebanon have natural immunity against SARS-CoV-2 (due to prior infection).
- With this estimated population-level immunity and with the vaccination campaign being still in early phases, gradual easing of all restrictions starting mid-April and introduction of new variants of concern is predicted to result in a new epidemic wave, of larger scale than the one experienced in December 2020.



Impact of vaccination on the scale of the epidemic

- Vaccination did not fully prevent a new epidemic surge because the current contact rate in the community is not sufficiently low and the population immunity level not sufficiently high, and because of the higher transmissibility of the new variants.
- Yet, reaching 80% vaccination coverage by the end of 2021 will noticeably flatten the epidemic curve, resulting in a smaller epidemic.
- Compared with the no vaccination scenario, 80% vaccine coverage will result in a 37% decrease in the peak daily number of infections, while the 40% coverage scenario will result only in an 11% decrease.
- More importantly, the 80% vaccination coverage would result in a 37% decrease in the peak daily number of severe and critical cases (needing hospitalization on that day) and a 34% decrease in the peak daily number of deaths compared with the no vaccination scenario, while the 40% coverage scenario will result only in an 11% decrease in each.

Impact of vaccination on cumulative COVID-19 hospitalizations and deaths

- Compared with the no vaccination scenario, 80% vaccine coverage is expected to avert more than 23,000 severe/critical disease cases and save more than 2000 lives in this year; a 3-fold increase in the number of prevented hospitalizations and deaths compared with 40% vaccine coverage rate.
- The sooner we reach the 80% vaccine coverage target, the higher the number of severe/critical disease cases we will avert and the more lives we will save (e.g. reaching 80% vaccine coverage by August 2021 would prevent twice as many hospitalizations and deaths than if it were reached by December 2021).
- A longer duration over which restrictions are eased would result in a more favorable impact of vaccination.

What should we do to safeguard population health?

- Scale-up vaccination coverage to reach the desired 80% vaccine coverage rate the soonest possible.
- Sustain certain levels of social distancing measures to obtain a more favorable impact of vaccination.

How can Lebanese authorities speed up vaccine rollout?

The results of our analyses clearly highlight the need to expedite vaccine rollout to achieve herd immunity with the least deaths and hospitalizations possible, and with the least damage to the economy in the short and longer term. Listed below are key strategies authorities can follow to overcome supply, demand and administration challenges, and speed up community immunization:

Supply

- Closely monitor data released by manufacturers to ensure the prompt approval of promising vaccines and their early procurement.
- Safeguard the early procurement of vaccines by providing manufacturers with needed national vaccination data for their ongoing monitoring and evaluation and purchasing the vaccines at a beneficial price for the producers.
- Secure various vaccine candidates, which puts the country ahead in its vaccine deployment campaign.
- Design a standardized policy to inform vaccinators of how to handle the remaining doses from no-shows.
- Promote the WHO-approved extraction of an additional jab than that indicated on the vial label for the maximal use of vaccine vials and provide the necessary guidelines for this use.
- Combat the limited availability of vaccine doses and the high disease burden by approving the delayed administration of the second dose when supported with scientific evidence.

Demand

- Suppress the spread of misinformation and vaccine hesitancy through a strategic communication plan, clear and tailored awareness campaigns, and community engagement initiatives.
- Organize targeted outreach initiatives to enhance the willingness of the public to get vaccinated, especially the most marginalized communities like refugees and migrant workers.
- Ensure geographical accessibility of all populations to vaccine administration sites by establishing them throughout all Lebanese regions and forming mobile vaccination teams to reach the distant areas.
- Ensure an equitable vaccine rollout by subsidizing vaccination costs for all residents through healthcare financing schemes and funding.

Administration

- Establish the largest possible number of vaccination sites to optimize vaccination rates and accessibility such as drive-through sites and field hospitals, and authorize administering vaccines in pharmacies and primary healthcare institutions.
- Continuously monitor and adjust the vaccine strategies according to the emerging evidence and data on the vaccines' safety and efficiency, the national epidemiological situation, and the vaccination campaign progress.
- Recruit a sufficient number of healthcare workers to deliver the vaccination program. This includes deploying retired healthcare professionals and military healthcare personnel.
- Procure the required personal protective equipment (PPE) and medical equipment for delivering the vaccines.
- Employ a centralized health information system to serve vaccine prioritization, outreach strategies, and monitoring.

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