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Impact of Public Health Interventions on the Spread of COVID-19 in Ontario

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Introduction

The COVID-19 pandemic has spawned over half a million cases in Ontario, Canada.

Public health interventions are being used to control its spread, but what would be their effect on the population in different scenarios?

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Objectives

What is the impact of not having the Winter 2020 or Spring 2021 province-wide lock-downs on the total number of positive cases, hospitalizations and deaths from COVID-19 in Ontario?

For different rates of vaccination, how long will it take Ontario to reach the target fully vaccinated population for reopening, as well as herd immunity?

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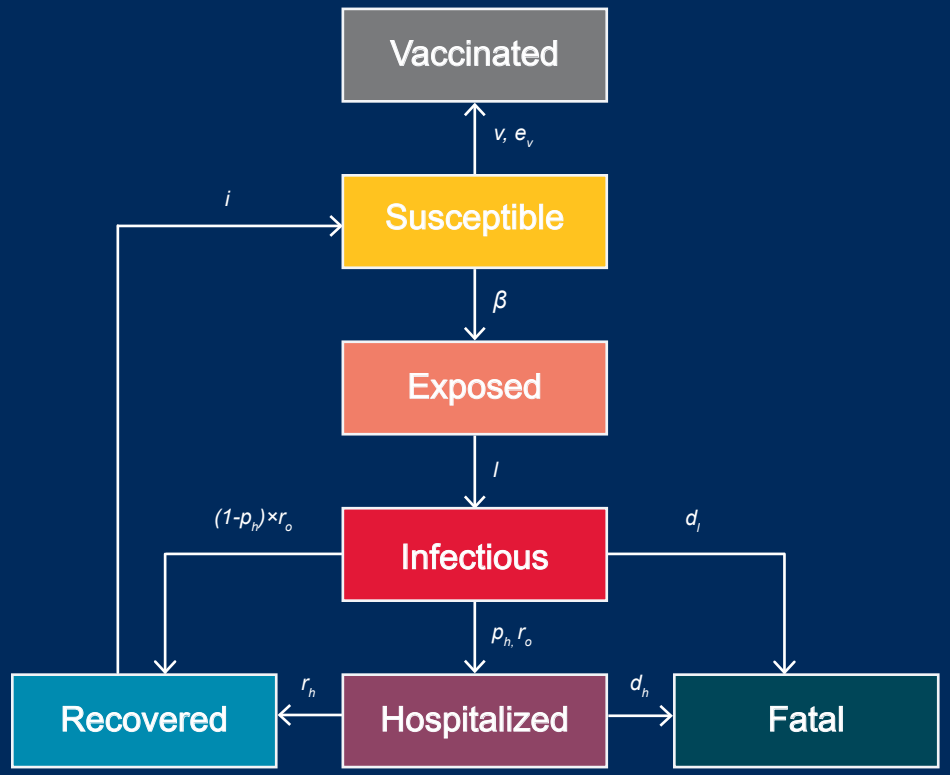
Methods

To simulate the COVID-19 epidemic in Ontario, we build upon the SEIR compartmental model by adding the states of Hospitalized (H), Fatal (F) and Vaccinated (V).



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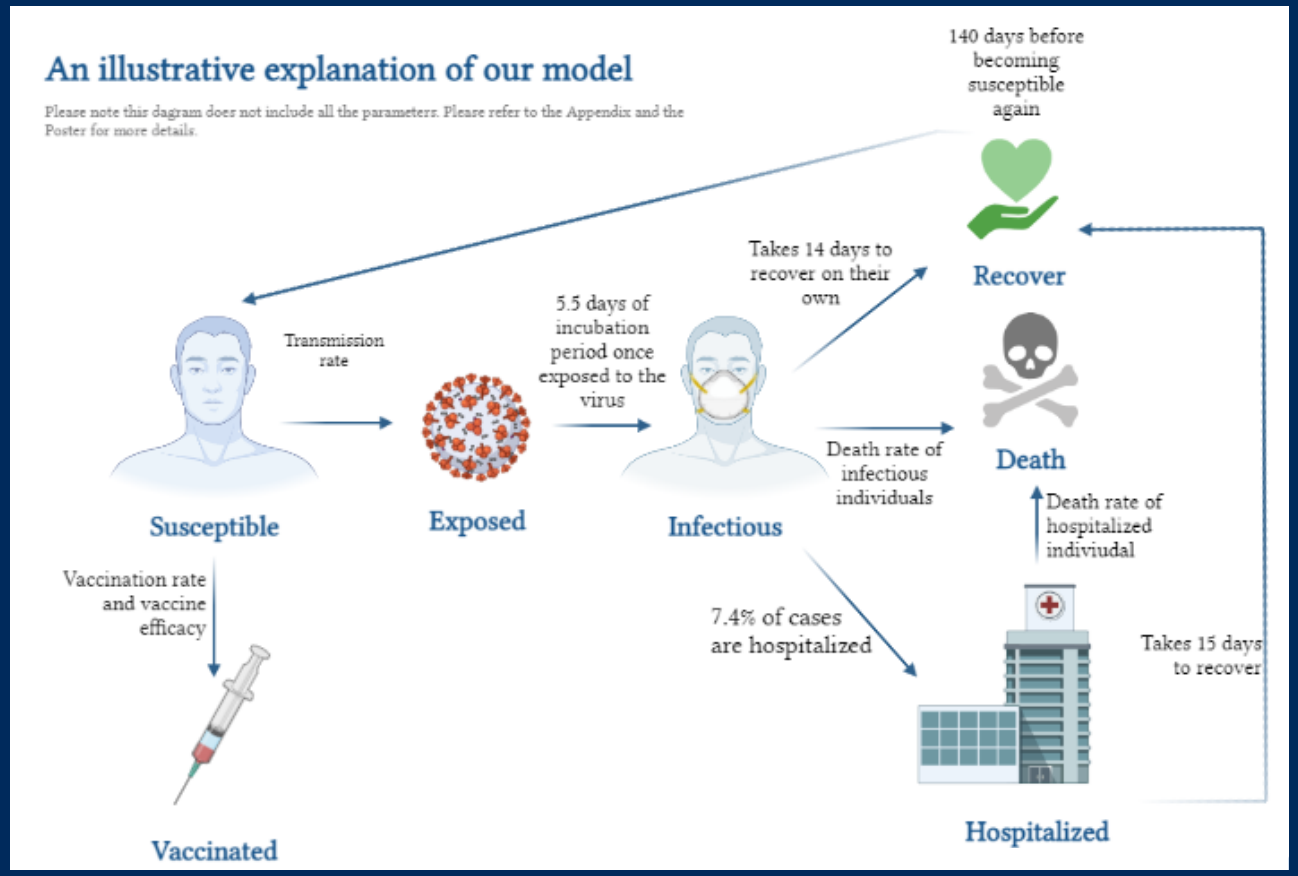

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Methods – Model Assumptions

The population size, N, remains constant over time.

The Vaccinated (V) state includes only fully vaccinated individuals

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Methods – Model Parameters

We modified the transmission rate, death rate, and vaccination rates to model different scenarios.

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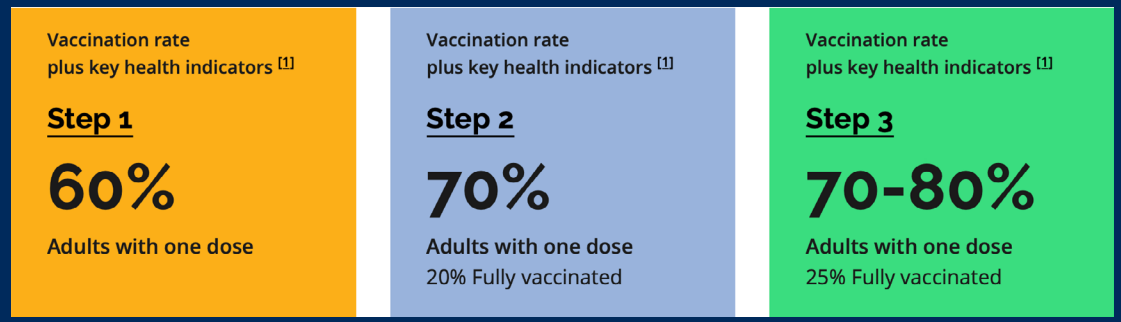
Methods

We looked at 2 lockdowns implemented by Ontario in Winter 2020 and in Spring 2021.

Additionally, we tested different vaccination rates to predict when 20% and 25% of the population would become fully vaccinated with 2 doses as defined in Steps 2 and 3 of the Ontario reopening plan, and 60% fully vaccinated which is the threshold for herd immunity.



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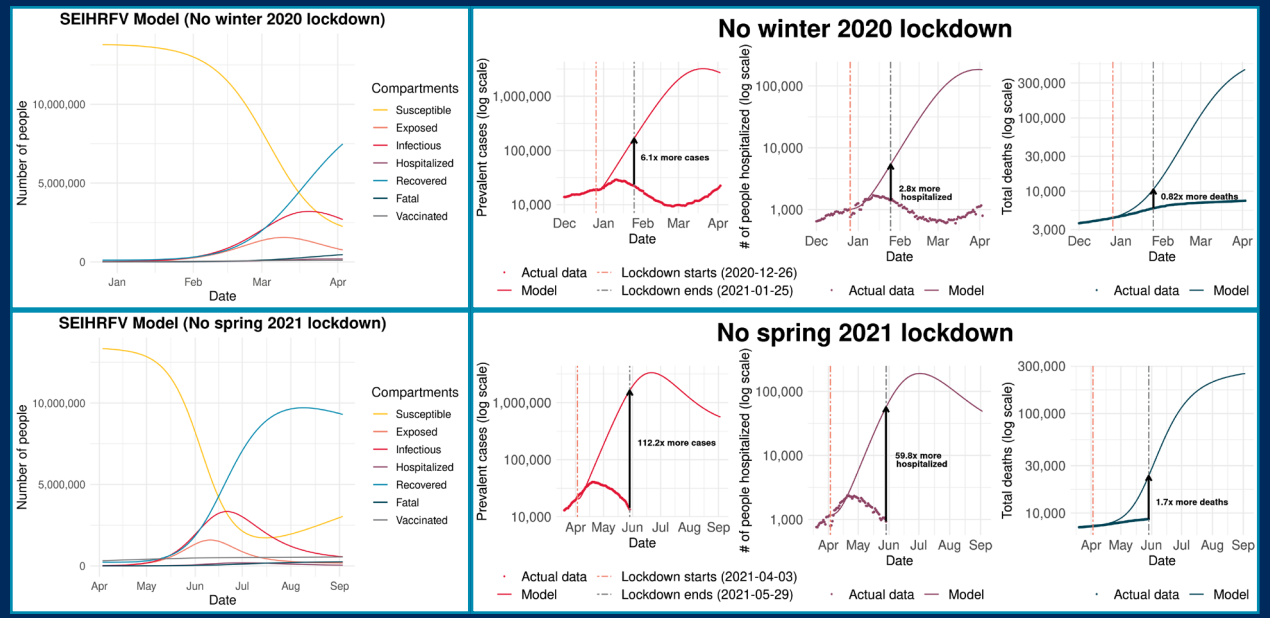
Results

The real data shows a decrease in the prevalent and hospitalized cases and a slowing down of fatal cases per day. Without either lockdown, our model suggests a continuously increasing trend where the prevalent, hospitalized, and fatal cases would be substantially higher.



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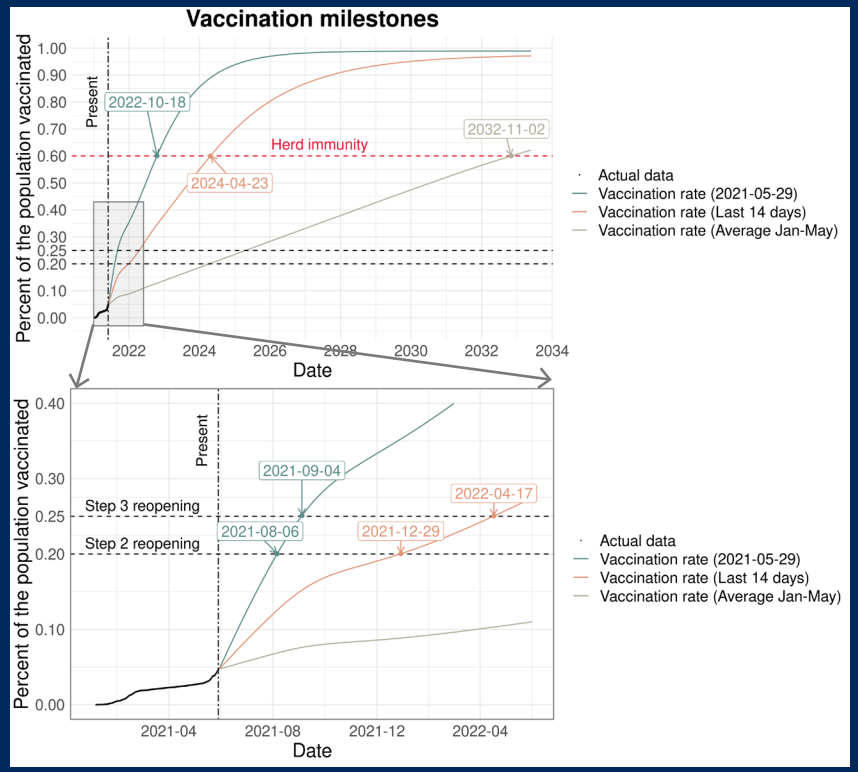
Results

Slowest vaccination rate:
It will take more than 10 years to reach herd immunity

Fastest vaccination rate:
Herd immunity can be reached before the end of 2022



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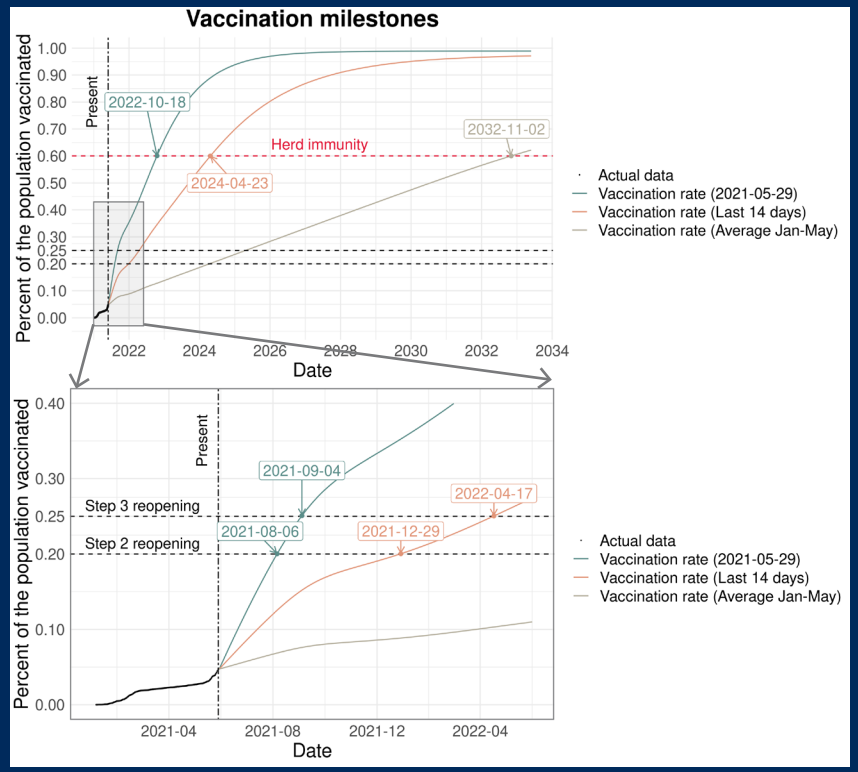
Results

If we keep the vaccination rate constant as of May 29, we can likely enter Step 2 of reopening.

If the vaccination rate is maintained at the average of the last 14 days from May 29, we can likely enter Step 2 in December, which is later than the target goal.



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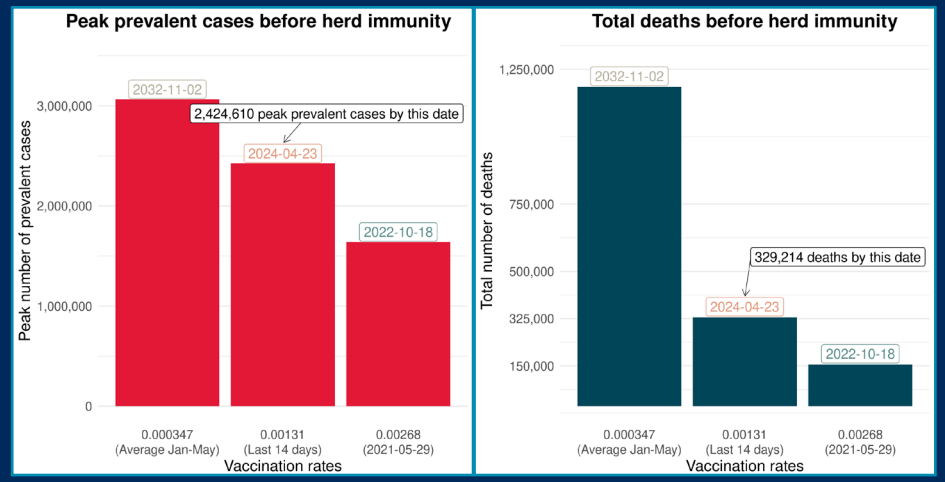
Results

As the three vaccination rates lead to herd immunity at different times, the number of deaths and peak prevalent cases would differ; specifically, slower vaccination rates result in more deaths and higher peak prevalent cases.



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Conclusions

Not having the province-wide lockdowns in Ontario would have led to considerably more prevalent cases, hospitalized individuals and deaths.

Higher vaccination rates would lower the number of peak positive(prevalent) cases and deaths by the time we reach herd immunity. Keeping the current rate of vaccination or faster would comply with the reopening timeline proposed by the Ontario government, and achieve herd immunity before the end of 2022.

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Strengths

We add the Hospitalized (H), Fatal (F), and Vaccinated (V) compartments to the SEIR model which gives a more complex and realistic simulation of the COVID-19 situation in Ontario.

Our model takes into account reinfection by including waning immunity.

We also extended previous research by predicting the time it will take for Ontario to reach herd immunity.

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Limitations

Our model assumes constant values for the parameters. In addition, our model did not take into account age-specific variation in contact rate, as well as birth rates and natural death rates in the population.

Our model did not evaluate the impact of other public health interventions such as wearing a mask and social distancing since with a combination of them already being in place in the province, it was difficult to isolate their effects from the data.

Additionally, in the herd immunity estimation, the actual vaccine effectiveness may not equal the vaccine efficacy, and with the variants of concern that we did not account for, the herd immunity threshold will be even higher.

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Thank you!

You can scan the QR codes to get access to our Appendix and References.

Appendix

References