Inferring the incidence of SARS-CoV-2 infection from wastewater and serological data

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Introduction

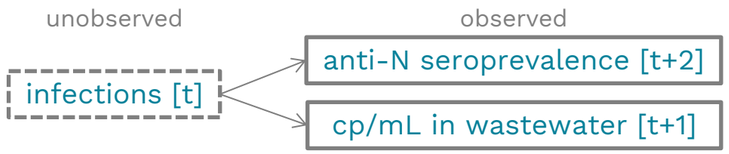
Serosurveillance can illuminate the extent of infection during a pandemic but SARS-CoV-2 seroconversion only occurs ~2 weeks after infection and serosurvey results are often released months after data are collected[1]. The concentration of SARS-CoV-2 in wastewater has been increasingly used to qualitatively identify regions with a relatively high prevalence of infectious individuals in a timely fashion[2]. In theory, **wastewater and serological data could be jointly analysed to develop timely and unbiased estimates of the incidence of infection within a population**, but there is a paucity of demonstrated approaches to doing so.

Objective

We aim to develop and evaluate statistical methods for using wastewater and serological data to infer the incidence of SARS-CoV-2 infection.

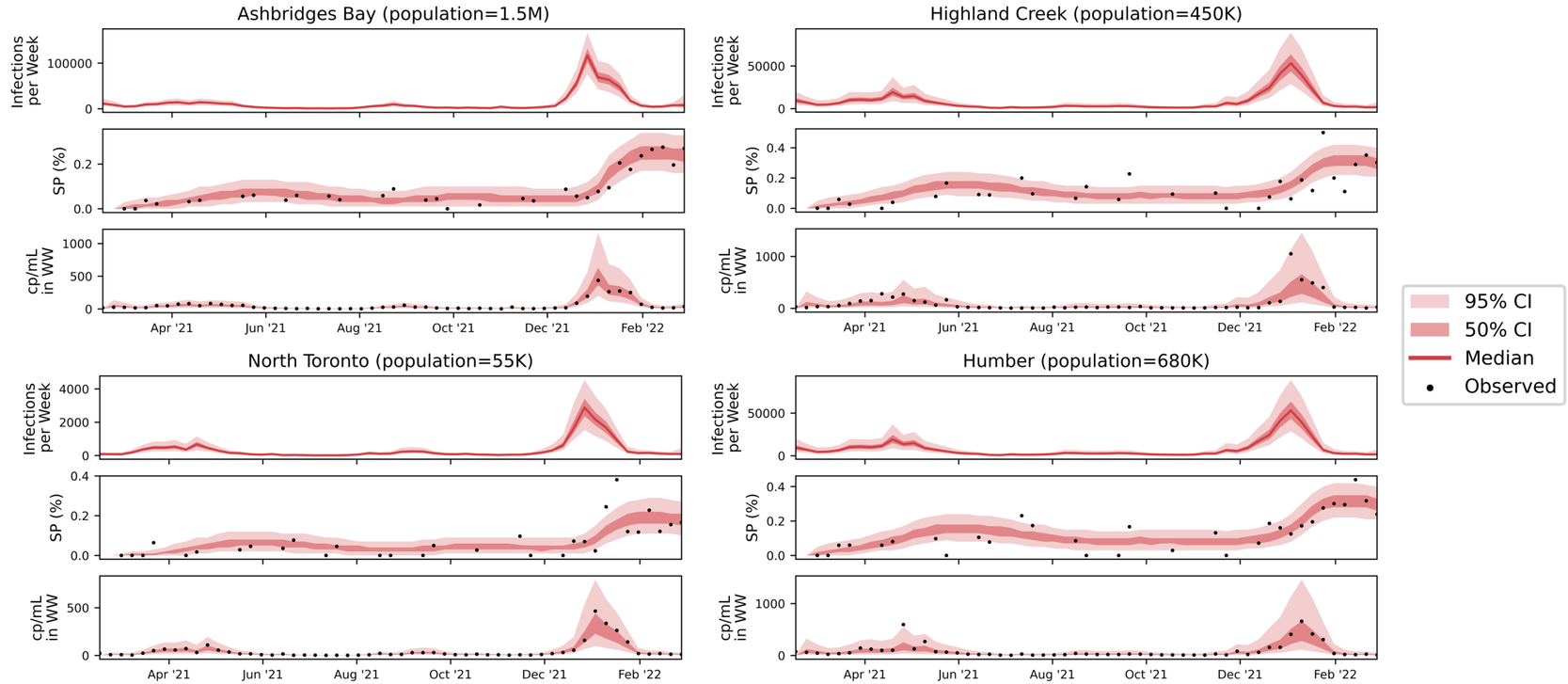
Methods

We used serological data sampled from blood donors, collected by Canadian Blood Services, together with wastewater data sampled from four wastewater treatment plants (WWTPs) in Toronto, collected by the municipality. We pre-processed these data into **weekly time series of the anti-nucleocapsid (anti-N) SARS-CoV-2 seroprevalence and of the concentration of SARS-CoV-2 (cp/mL) in wastewater**. Then, to estimate the incidence of SARS-CoV-2 infection, we fit a Bayesian statistical model in which these two epidemiological signals are generated from an underlying, unobserved infections process.



Results

Figure 1. Modelled weekly infections, anti-N seroprevalence (SP), and concentration of SARS-CoV-2 (cp/mL) in wastewater (WW).



Model diagnostics: R-hat and effective sample size were acceptable. Only ~0.2% of iterations ended with a divergence.

Conclusions

We estimated that up to ~10% of the population was infected per week during the first Omicron wave. Next, we plan to incorporate other wastewater-relevant factors[3] (e.g., precipitation, temperature) into our model and validate the model past March 2022. We will also expand the geographical scope of analysis to 13 other WWTPs beyond Toronto and explore hierarchical model structures.

References

1. Donnici et al, Epidemics (2021).
2. Shah et al, Science of The Total Environment (2021).
3. Li et al, Chemical Engineering Journal (2021).

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