Work Package 2 – LGA Substream

Table of Contents

Key Messages

- Baseline transmission potential (TP) differs by small area, as do vaccine and PHSM impacts (ability to work from home).
    - Drivers include larger mean household size (leading to more household contacts), larger working-age populations (leading to more workplace contacts) and social determinants such as housing quality and crowding.
    - These factors tend to be geographically clustered and are often reported at the LGA-level.
    - Such variation also influences likely vaccine impacts at subpopulation level as LGAs with a higher proportion of children will be more likely to observe ongoing transmission in those aged less than 12 years, who are currently ineligible for vaccination.
    - In addition, inability to work from home reduces the impact of public health stay at home orders, and often correlates with higher baseline and post-vaccination transmission potential.
    - A model based on employment industry type correlates well with empirical survey data reporting ‘working from home’ under lockdown, by local government area (LGA).
- Focussed TTIQ and wrap around supports will be needed to constrain TP in high-risk areas, not lockdowns, and may include additional measures in schools and workplaces.

Aims

The national vaccination targets will have different effects across different sub-populations. Areas of socio-economic disadvantage are likely to require higher vaccination thresholds compared to the average to achieve a target level of control because of differences in baseline transmission potential and related impacts of vaccine coverage.

Here, we adopt the transmission potential framework used in previous pieces of modelling advice to account for these location specific differences.

The transmission potential (TP) represents average or expected transmissibility of SARS-CoV-2 in a population. In previous work and weekly situational assessment, we estimate and report on TP at a state-level. By adjusting the TP for various spatial factors, we can measure this expected transmissibility at the level of Local Government Areas (LGAs) rather than states.

Key questions

1. What is the spatial variability in the underlying ability for SARS-CoV-2 to spread in the population?
2. How much can this be modified with vaccination?
3. How much can this be modified with strong public health and social measures (PHSMs)?

Transmission potential at LGA level

Baseline TP and the effect of vaccination will vary by LGA, based on age profile. The vaccine rollout does not currently target children under 12 years of age, and so in LGAs with a high proportion of children, the relative impact on transmission of a vaccine will be reduced.

Experience has also shown that the ability of lockdowns to modify mixing and so reduce transmission differ across geographical areas. While a number of behavioural changes result in PHSM impacts, the ability to work from home can be anticipated with reasonable certainty based on occupation and validated on the basis of survey data. In some LGAs, there is a high proportion of people whose work cannot be done remotely and are considered 'essential', who will continue to have workplace contacts even under the most restrictive of PHSMs.

The combination of an increased baseline TP, lower vaccination coverage and lower PHSM effect combine to make understanding of these spatial differences complex, as highlighted in Figure 1. In many locations, these factors – population structure, vaccine impact, and ability to adhere to lockdowns – co-occur with socioeconomic disadvantage.

Figure 1 shows how population characteristics influence baseline transmission potential (upper limit of salmon bars) and vaccine impacts (blue shading) between 50 and 80% coverage. Compared with the 'all Australian' population, small area TP and vaccine impacts will be heterogeneous, as demonstrated by five exemplar LGAs each for greater Melbourne and Sydney.

Kingston (left panel) and Sutherland Shire (right panel) are most 'typical' of the national average. Affluent areas comprised of small households and a high proportion of working age adults (Port Phillip, Stonnington, North Sydney, Mosman) have an average baseline TP but larger than average vaccine change impacts. Areas like Greater Dandenong and Fairfield have a higher than average proportion of working age adults, which accounts for a higher starting TP but also marked reductions achieved following vaccination. Murrindindi and Oberon both have lower baseline transmission potential and vaccine impacts arising from higher proportions of children and older adults than the national average, respectively.

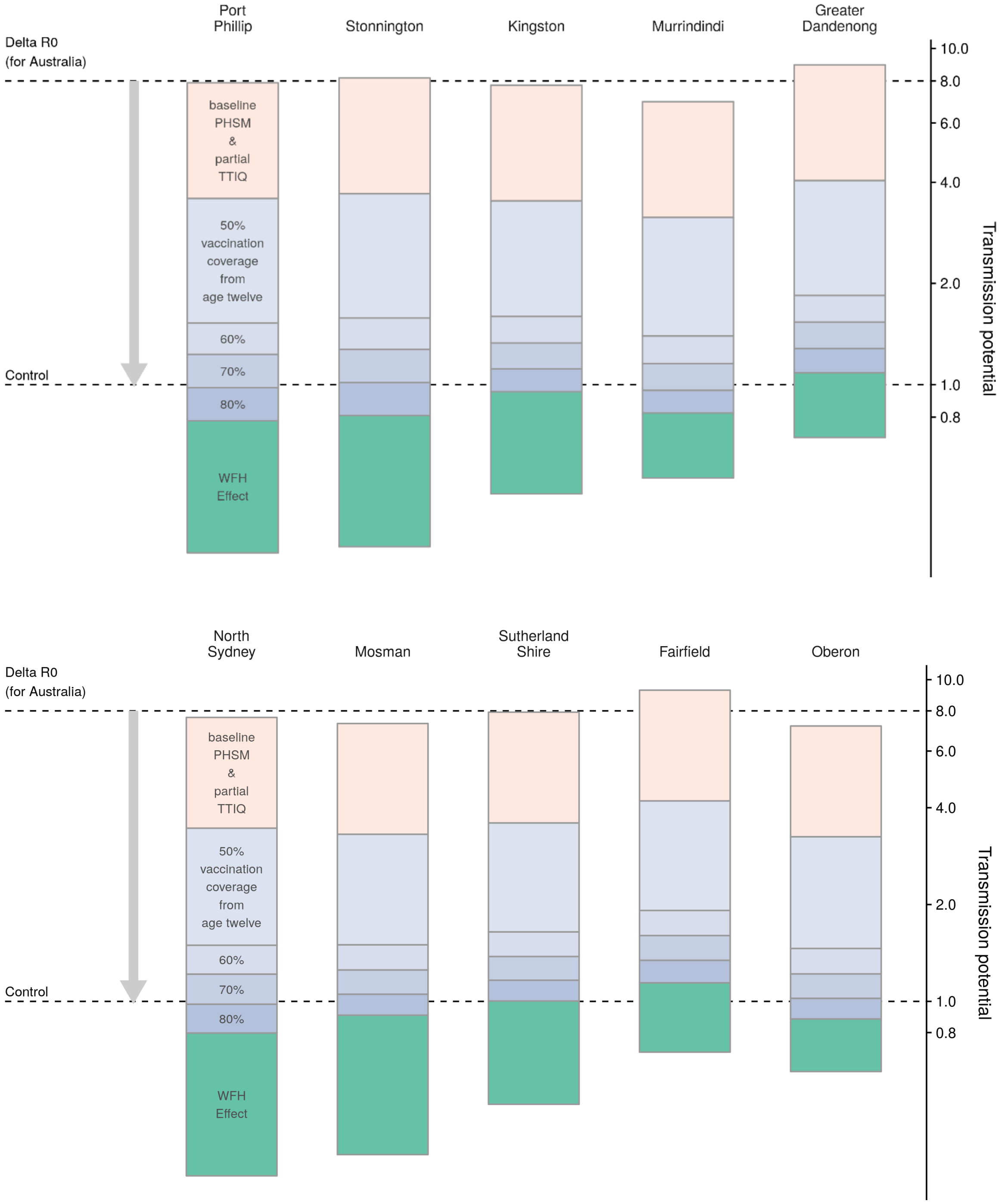

Figure 1: Visualisation of baseline TP, vaccination effect and ability to work from home on the overall TP achievable for LGAs in Greater Melbourne (upper panel) and Greater Sydney (lower panel)

Varying ability to work from home is reflected in the differences between the green components of Figure 1. Port Phillip, Stonnington, North Sydney and Mosman have large population proportions in professional occupations that are amenable to stay at home working. Greater Dandenong and Oberon each have higher than the national average proportion of machinery operators and labourers, who cannot work from home. Murrindindi and Fairfield have a larger than average proportion of children who are not in employment, lessening the impact of work from home requirements on overall levels of mixing in these areas under public health orders.

Spatial variability in transmissibility

Figure 2 maps the estimated transmission potential for LGAs in the Melbourne and Sydney Metropolitan areas. These baseline transmission potentials include LGA-specific R0 estimates (as per Figure 1) with the assumed effects of baseline PHSMs and partial TTIQ (i.e. these are comparable to a national TP of 3.6). Note that the resident populations of major city-centre LGAs (e.g. Melbourne and Sydney) have a very high transmission potential when considered by this metric, due to the small numbers of school-age children living there. However, in reality, CBD residents will have many contacts outside of the LGA, making these unreliable estimates of transmission in these settings.

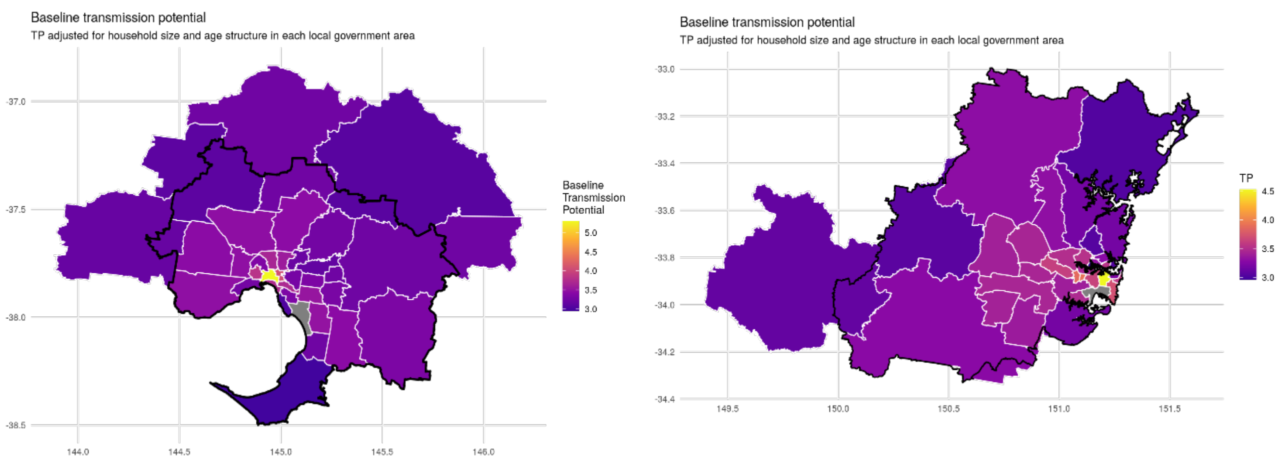

Figure 2: Baseline transmission potential, including differences in age structure and mean household size, by LGA in metropolitan Melbourne (left) and Greater Sydney (right).

Overall, many LGAs are below the national average transmission potential (calibrated to be 3.6, in line with previous national modelling work), although generally the risk increases the closer an LGA is to a metropolitan centre.

Note that this work focusses only on structural changes in the population (age structure and household size) and translates these into changes in contact patterns. It does not consider the measured changes in contact patterns in population subgroups. Substantially more observational data would be required to capture these patterns at a smaller resolution

Spatial variability in impact of vaccination

Figure 3 maps the percentage reduction in TP in each LGA from the baseline TP in Figure 2 to the TP expected after 80% coverage of the 12+ population. This includes a proportion of the population having received only a single dose as in the phase 1 report. There appears to be significantly more variation in this quantity than baseline TP. Further, the baseline transmission potential is not correlated with the percentage reduction, since changes in the numbers of contacts due to age structure and household size are not exactly offset by the effect of vaccination.

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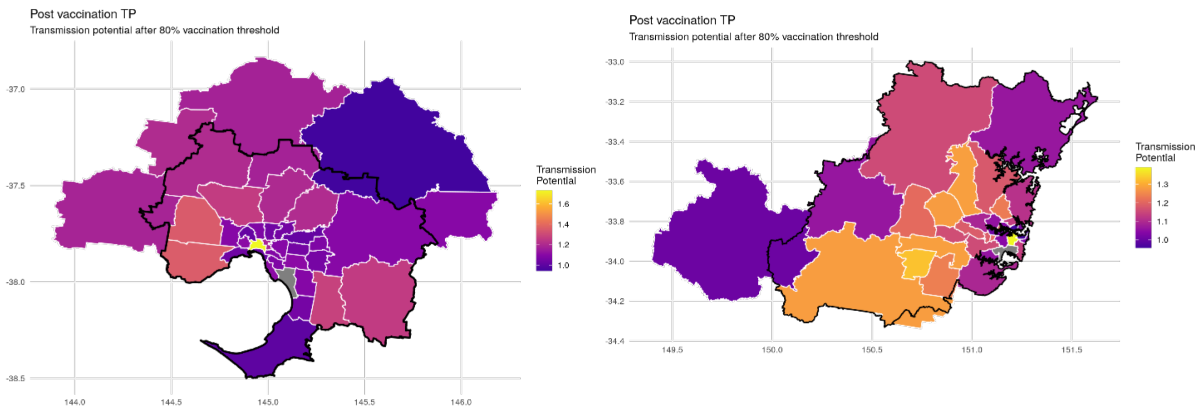

Figure 3: Transmission potential including the reduction due to vaccination at 80% coverage, by LGA in metropolitan Melbourne (left) and Greater Sydney (right).

Spatial variation in the ability for lockdowns to reduce TP

While an LGA (or region of an LGA) may have a high baseline TP, an important factor if infection is established is the ability for response measures to modify (reduce) that TP. It should not be assumed that regions with a higher baseline TP as necessarily those for which TP under lockdowns is also highest. Similarly, LGAs with an intermediate baseline TP may vary in how much change can be induced.

Within an LGA the proportion of working-age adults who are able to work from home is a possible metric for the population's ability to reduce their out-of-home contacts (and thus TP). Analysis of weekly-collected survey data shows variation in the proportion of individuals reporting to be working from home across LGAs under different levels of restrictions (Figure 4).

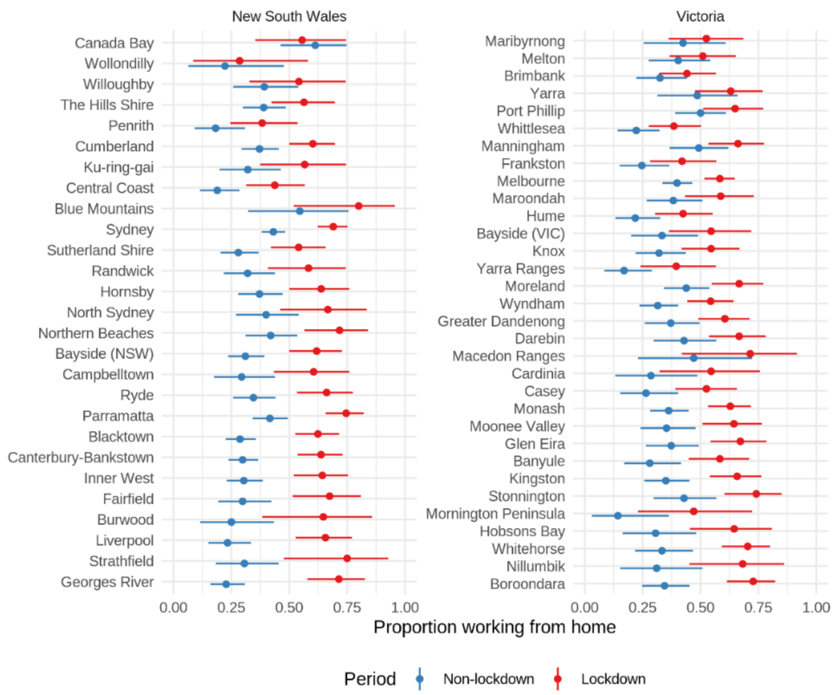

Figure 4: Survey responses on whether individuals are working from home or not, during lockdown and non-lockdown periods.

The survey data is relatively sparse, particularly in regional areas, and is difficult to extrapolate to all LGAs. To address this, we assess the correlation between the survey responses and the ability to work from home derived from occupation data from the 2016 census (1,2), termed the "modelled WFH ability". For metropolitan LGAs, the modelled WFH ability correlates well with survey-based responses. For non-metropolitan LGAs, there is insufficient resolution in available data to assess the validity of the approach (Appendix A: Validation of modelled WFH ability).

Figure 5 shows the modelled WFH ability for metropolitan Melbourne and Greater Sydney. As with the other measures, there is clear visible heterogeneity across the region, although the likelihood of being able to WFH appears correlated with proximity to a city centre.

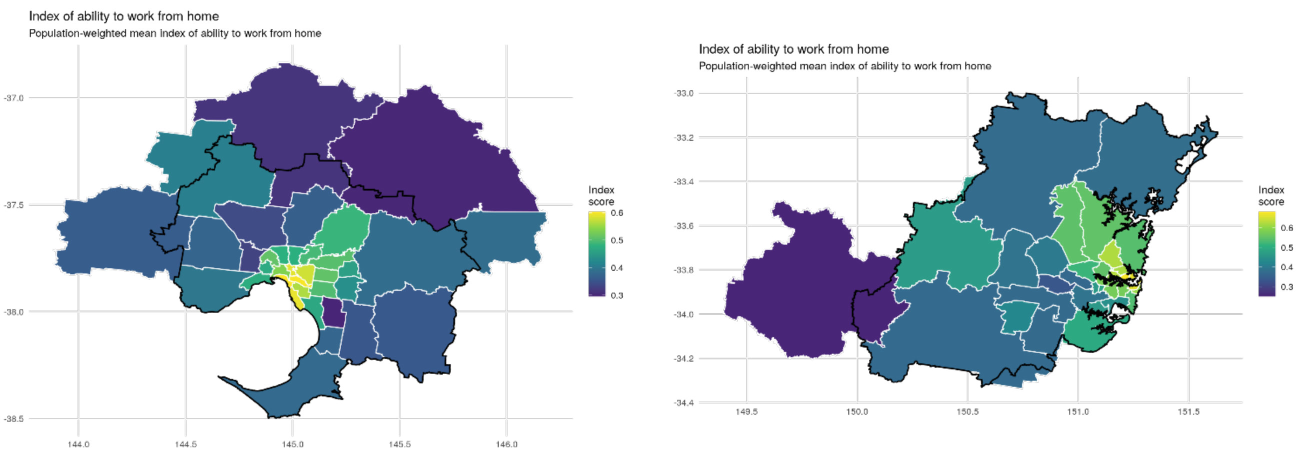

Figure 5: Modelled WFH ability for metropolitan Melbourne and Greater Sydney.

Sub-LGA heterogeneity

We anticipate heterogeneity in lockdown impacts at the sub-LGA level. If managing the epidemic at an LGA level, the required response will likely by driven by sub-sections of the LGA with the lowest ability to reduce out-of-household contacts and thus reduce transmission.

As the modelled WFH-ability is based on census data, it can be evaluated at different spatial scales to assess the variability. Figure 6 shows the modelled WFH-ability calculated for each SA2 that makes up an LGA, ordered by the lower confidence interval (left-hand endpoint of the black line). This figure highlights how the heterogeneity varies across LGAs, with areas such as Liverpool and Canterbury-Bankstown in NSW, as well as Brimbank and Mornington Peninsula in VIC having very high heterogeneity.

Where there is high variability within an LGA, the ability of the virus to spread in certain sub-populations may be higher than the population average (the LGA-wide TP). Sub-LGA analyses may reveal populations at-risk and therefore guide anticipated needs. Insight into sub-LGA level epidemic dynamics could be gained in real-time by comparing observed epidemic growth (R_{eff}) to LGA-level TPs.

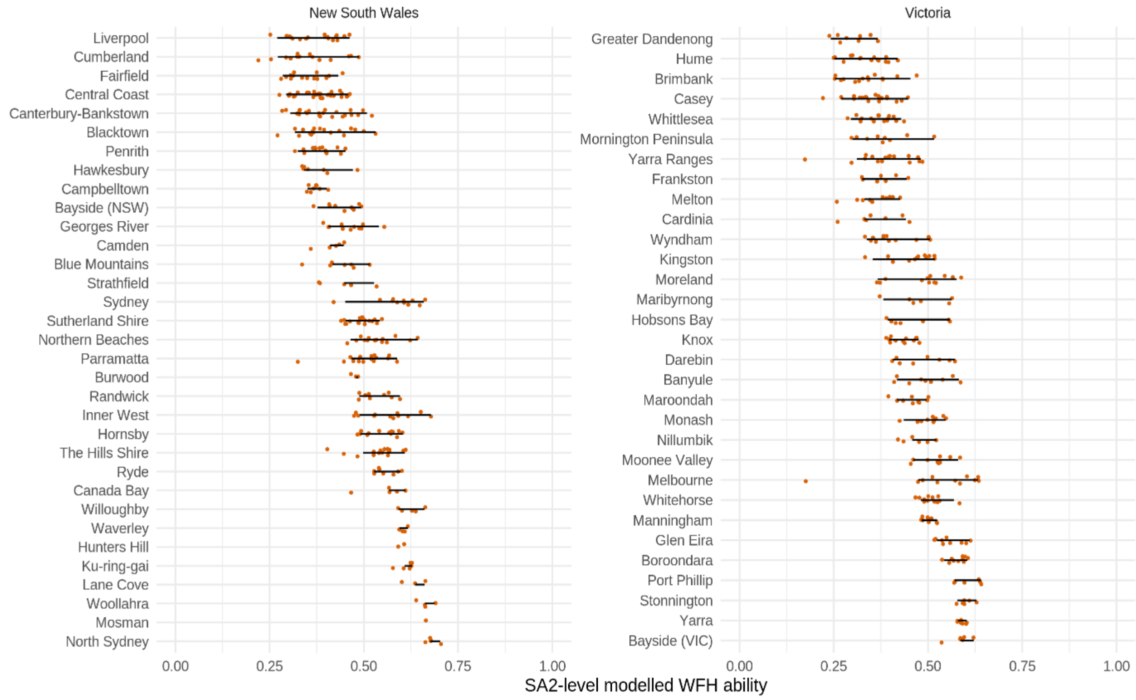

Figure 6: Proportion and 95% CI of modelled WFH ability in Greater Sydney and metropolitan Melbourne, calculated on each SA2 that is part of an LGA.

WFH Effect on TP

The WFH Effect, represented by the green bars in Figure 1, is calculated for each LGA and shown in Figure 7 assuming a static 80% vaccination coverage in each LGA. Here, the ability to WFH is much greater in city centres compared to the more regional areas. When all factors are included – vaccination, WFH effects and TTIQ measures – the transmission potential generally increases further away from city centres, indicating the reduction in transmission risk gained from WFH measures is critical in keeping case numbers in control, and that is far less effective in more regional centres.

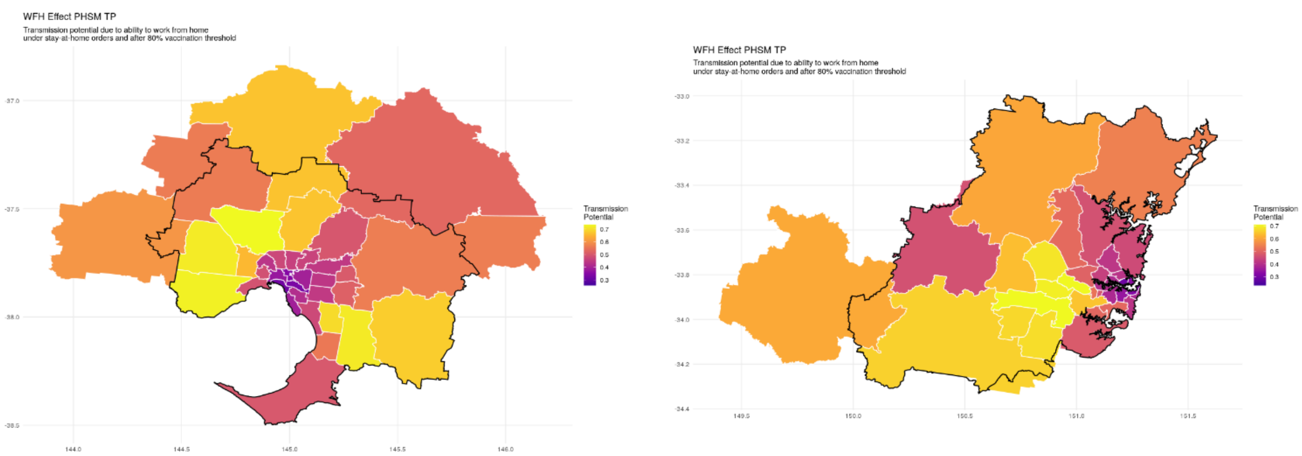

Figure 7: Transmission potential including 80% vaccination coverage, population demographics, and WFH effect, for metropolitan Melbourne and Greater Sydney.

Summary and next steps

This work has thus far shown that the heterogeneity in population factors is complex and multi-faceted. For example, an increase in baseline TP does not necessarily correlate to an increased risk at high vaccination thresholds.

It must also be stressed that LGAs are large geographical structures, and sub-structures within these areas may drive the behaviour of the entire LGA. Targeted measures, including increased messaging and community engagement, could have a greater impact than in more homogenous areas.

WFH measures have a highly varied effect across space. Stay at home orders will not necessarily mitigate importation and outbreak risks in many LGAs that would be anticipated to have higher than average ongoing risks of transmission, even with high 12+ vaccine coverage. Focused TTIQ responses, wrap around supports and school and workplace measures are more likely to effectively reduce transmission and disease impacts in these settings.

References

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Appendix A: Validation of modelled WFH ability

The modelled WFH ability was compared to the survey-based responses to working from home. These measures differ slightly in that the survey responses measure whether an individual *is* working from home, whereas the modelled WFH ability measures whether an individual *can* work from home. Figure 8 shows the modelled WFH ability score against the empirical survey responses, by non-lockdown and lockdown periods. There is a visible correlation between the two measures, although the trend appears somewhat confounded by the LGAs of concern in NSW, and the differences in what public health measures were applied across the state.

Figure 9 is a Bland-Altmann plot, showing the difference in modelled WFH ability and the survey responses, against the modelled WFH ability, stratified by whether an LGA is metropolitan or regional. Good model performance is represented by the points being contained in a single horizontal band. For metropolitan LGAs, this visually appears true.

There is a constant bias between the two measures, indicating that more people are going to work who could have worked from home according to the model. This bias will be captured in the quantification of how WFH affects the number of workplace contacts in the TP model.

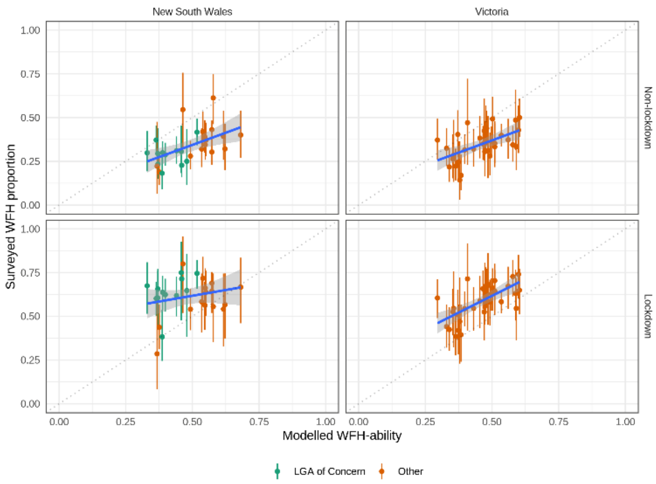

Figure 8: Modelled WFH ability against survey-based responses for NSW and VIC, separated by non-lockdown and lockdown time periods.

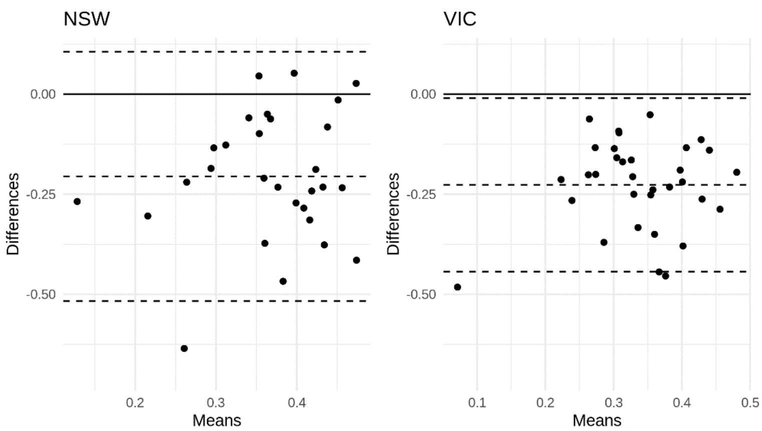

Figure 9: Bland-Altmann plot considering modelled WFH ability and survey based responses.