Changes in admission rates to an Aotearoa New Zealand hospital general medical service during COVID-19 lockdowns

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ABSTRACT

AIM: To better understand the reasons for reduced hospital admissions to a hospital general medicine service during COVID-19 lockdowns.

METHODS: A statistical model for admission rates to the General Medicine Service at Wellington Hospital, Aotearoa New Zealand, since 2015 was constructed. This model was used to estimate changes in admission rates for transmissible and non-transmissible diagnoses during and following COVID-19 lockdowns for total admissions and various sub-groups.

RESULTS: For the 2020 lockdown (n=734 admissions), the overall rate ratio of admissions was 0.71 compared to the pre-lockdown rate. Non-transmissible diagnoses, which constitute 87% of admissions, had an admission rate ratio of 0.77. Transmissible diagnoses, constituting 13% of admissions, had an admission rate ratio of 0.44. Reductions in admissions did not exacerbate existing ethnic disparities in access to health services. The lag in recovery of admission rates was more pronounced for transmissible than non-transmissible diagnoses. The 2021 lockdown (n=105 admissions) followed this pattern, but was of shorter duration with small numbers, and therefore measures were frequently not statistically significant.

CONCLUSIONS: The biggest relative reduction in hospital admission was due to a reduction in transmissible illness admissions, likely due to COVID-related public health measures. However, the biggest reduction in absolute terms was in non-transmissible illnesses, where hospital avoidance may be associated with increased morbidity or mortality.

Significant decreases in admissions were anecdotally observed in acute hospital general medical services (known as "internal medicine" in some jurisdictions) in Aotearoa New Zealand during the COVID-19 lockdowns of 2020 and 2021.

This trend has been reported as affecting emergency department presentations, hospital admissions and specific disease categories (such as acute myocardial infarction and stroke) across a number of countries.[1–6] These studies illustrate reductions in both urgent and routine medical encounters across all age groups, with, in some cases, a greater impact on minority ethnic groups. Reduced presentations of transmissible compared to non-transmissible medical illnesses in this setting has not been previously studied.

This reduction in overall admissions was also observed in the General Medicine Service (GMS) of Wellington Regional Hospital (WRH)—a service covering Aotearoa New Zealand's capital that admits, on average, approximately 7,500 adult patients a year. Admissions are for a wide variety of medical diagnoses, but exclude acute coronary syndromes, strokes and most admissions for the treatment of cancer.

Possible reasons for this reduction in admissions during these lockdowns are wide ranging and not well understood. In Aotearoa New Zealand, lockdown rules[7] prohibited leaving home except for workers in specifically defined essential services and to obtain essential household supplies. Masks were mandatory outside of home. Hospital attendance was an acceptable exception to lockdown rules. Lower rates of all transmissible diseases due to public health measures aimed at reducing COVID-19 transmission could have led to reduced admissions (a positive impact). Reduced admissions could also have resulted from, for example, a fear of contracting COVID-19 in the process of getting to or being admitted to hospital ("hospital avoidance"),[8,9] or from difficult access to primary care resulting in reduced referral to hospital (negative impacts). Services normally provided in a hospital setting could also have been specifically organised in a

community setting or via telehealth as an alternative to hospital admission ("hospital diversion").

We undertook a retrospective cohort study on admission data to the WRH GMS. In this study, we aimed to delineate admissions for transmissible infectious diseases and non-transmissible illnesses to better understand the impact of lockdowns on access to hospital services. We modelled long-term rates of admission for both transmissible and non-transmissible diagnoses and examined how these rates were affected by the 2020 and 2021 lockdowns. We further evaluated if there were lags in changes to these rates during and after these lockdowns, and also if these rates varied by sub-groups; specifically, ethnicity, socio-economic deprivation, rest home residents, age groups and those who died while in hospital compared to those who did not.

Methods

Anonymised data for all admissions to the WRH GMS from January 2015 to January 2022 were obtained from the electronic patient management system. This period included two lockdowns: 23 March to 13 May 2020 (52 days, n=734 admissions) and 31 August to 7 September 2021 (8 days, n=105 admissions). For the purposes of this study, Alert Levels 3 and 4 were considered "lockdown", as these were the levels that imposed significant, population-wide restrictions. The difference between total admission rates for Alert Level 3 and Alert Level 4 was not statistically significant (p=0.50); thus, combining these periods for analysis was considered appropriate. Resident population estimates were sourced from Statistics New Zealand | Tatauranga Aotearoa.[10]

The principal diagnosis for each admission was determined from Diagnostic Related Group (DRG) codes.[11] Each principal diagnosis was categorised as "transmissible", "non-transmissible" or "mixed" by a manual categorisation of the approximately 500 DRG codes in the dataset.

For example, transmissible diagnoses included gastroenteritis (G67A) and respiratory infections (E62A). Cellulitis (J645A) was considered non-transmissible, as, in the adult setting, it is infrequently associated with inter-personal transmission despite being an infectious illness. Some diagnoses, particularly non-specific respiratory illnesses (e.g., Other Respiratory System Disorders [E75B]) were considered as "mixed" and excluded from the analysis, as a transmissible infection may precipitate the illness, but this is often uncertain

even at discharge. For the purposes of this study "total" admissions refers only to admissions able to be categorised as "transmissible" or "non-transmissible" and excludes mixed diagnoses.

A statistical model was developed. Input data included age, sex, ethnicity, rest home status, New Zealand Index of Deprivation (based on the patient's postcode), season and transmissibility status.

Poisson regression was initially used to model weekly GMS admission rates. Predictor variables included season (summer, autumn, winter, spring), lockdown period (pre-lockdown, 2020 lockdown, 2021 lockdown), and an interaction between disease classification and lockdown. Population size was used as an offset variable. This model showed significant evidence of over-dispersion (ϕ = 2.6).[12]

A negative binomial model was therefore used, including the same input variables (the primary model).

This primary model is presented. To investigate whether the findings were consistent across various predefined sub-groups, additional models were fitted with the specified sub-groups as inter-action terms with lockdown. Sub-groups were pre-defined as:

- Ethnicity (Māori/Pacific/Other)
- Socio-economic status (very deprived/deprived/not deprived; based on postcode-derived New Zealand Deprivation Index groupings of 1–2, 3–5 and 6–10, from NZDep13 and NZDep18)
- Age group (16–64/≥65)
- Rest home resident (yes/no, derived from the WRH patient management system)
- Died as an inpatient (yes/no)

Analysis of the primary model was again repeated using fortnightly periods throughout the lockdowns and immediately following to investigate potential tapering off and on of admissions. Our hypothesis was that rates of admission for:

- transmissible diseases would initially be sustained by the incubation time and infectious period of already circulating infectious illnesses or in-home transmission, and then taper off during and beyond lockdown due to the sustained interruption to transmission of infectious diseases;
- non-transmissible diseases would initially decline, but then drift back up, as initial

anxiety about contracting COVID-19 lessened, and the need of addressing serious illness forced admission.

All applicable tests have been performed using a 5% significance level. Analysis was performed using SAS version 9.4 and R version 4.0.4. Charts were produced in SAS.

Ethics

This study was out of scope for the Health and Disability Ethics Committee. Approval was obtained by the WRH Clinical Audit Committee.

Results

The dataset used for analysis contained 47,407 records, as in the STROBE diagram (Figure 1).

Data summary

The 47,407 admissions used to construct the primary model exclude 4.8% of the provided admission records that had no DRG, and 3.7% whose primary DRG was classified as mixed (i.e., transmissible/non-transmissible status unable to be determined from the diagnostic code). Of the admissions included in the primary model, 13% were for transmissible diagnoses and 87% for non-transmissible.

Both lockdowns saw statistically significant decreases in admissions for transmissible and non-transmissible causes (Figure 2). The second lockdown was very brief, and the impact is therefore attenuated.

The patient characteristics of the 47,407 analysed admissions are shown in Table 1.

The primary model showed a significant effect for season (p<0.001). Overall rates of admission in summer and autumn were statistically significantly lower than winter: rate ratios were 0.88 (95% confidence interval [CI] 0.84–0.92, p<.0001) and 0.93 (95% CI 0.88–0.98, p=0.006) respectively. There was not a significant difference in rate between spring and winter: the rate ratio was 0.98 (95% CI 0.92–1.03, p=0.35).

Sub-group and lag analysis for the 2021 lockdown is not presented. While the overall pattern was similar, small numbers made results largely not statistically significant.

Impact of lockdowns on adjusted admission rates

Adjusted admission rates per 100,000 population were estimated using the primary model (Table 2). Compared to the pre-lockdown period, rates of admission were significantly lower during the 2020 lockdown for each of total transmissible and non-transmissible diagnoses, and during the 2021 lockdowns for transmissible diagnoses only.

For the 2020 lockdown, the percent decrease in admission rate due to transmissible causes was statistically significantly larger than the percent decrease for rates of non-transmissible causes, with the transmissible rate ratio being 1.77 (95% CI 1.30–2.42, p=0.0003) times larger than non-transmissible rate ratio. For the 2021 lockdown, the non-transmissible rate ratio was 1.58 (95% CI 0.7–3.60, p=0.27) times larger than transmissible rate ratio (Figure 3).

Sub-group analyses for the 2020 lockdown

Figure 4 presents the sub-group analysis for the 2020 lockdown by transmissible and non-transmissible disease. A statistically significant interaction term suggests that the lockdown response differs in relation to the sub-group. The interaction plots show the estimate rate ratios with 95% CI for each sub-group.

There was a significant interaction with the lockdown period for ethnicity overall (p=0.015), but with Māori and Pacific peoples not having a statistically significant decrease in non-transmissible admissions during the 2020 lockdown. Likewise, patients who died during their admission for non-transmissible cases also did not decrease. There were no significant differences for total admissions between age groups, socio-economic status and rest home status.

Lags within and following the 2020 lockdown

Figures 5 and 6 show the fortnightly trend within and following the 2020 lockdown for transmissible and non-transmissible diagnoses respectively.

The admission rate for transmissible illnesses declined through the lockdown and remained low following. For non-transmissible illness, the admission rate declined for the first month, but had returned to be consistent with the baseline well before the end of the lockdown.

Discussion

This discussion focusses on the 2020 lockdown. While the 2021 lockdown in general mimicked the
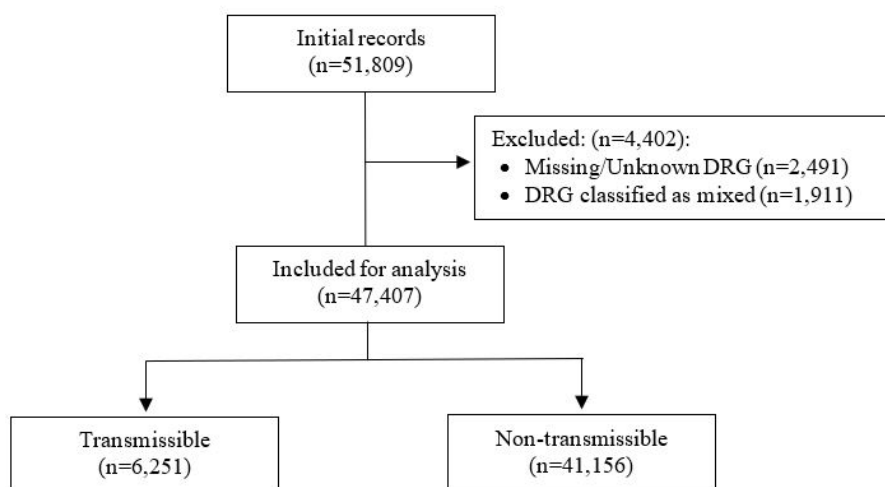
Figure 1: STROBE diagram.

Figure 2: Monthly admissions to WRH GMS by disease type. Shaded areas represent the two lockdowns.
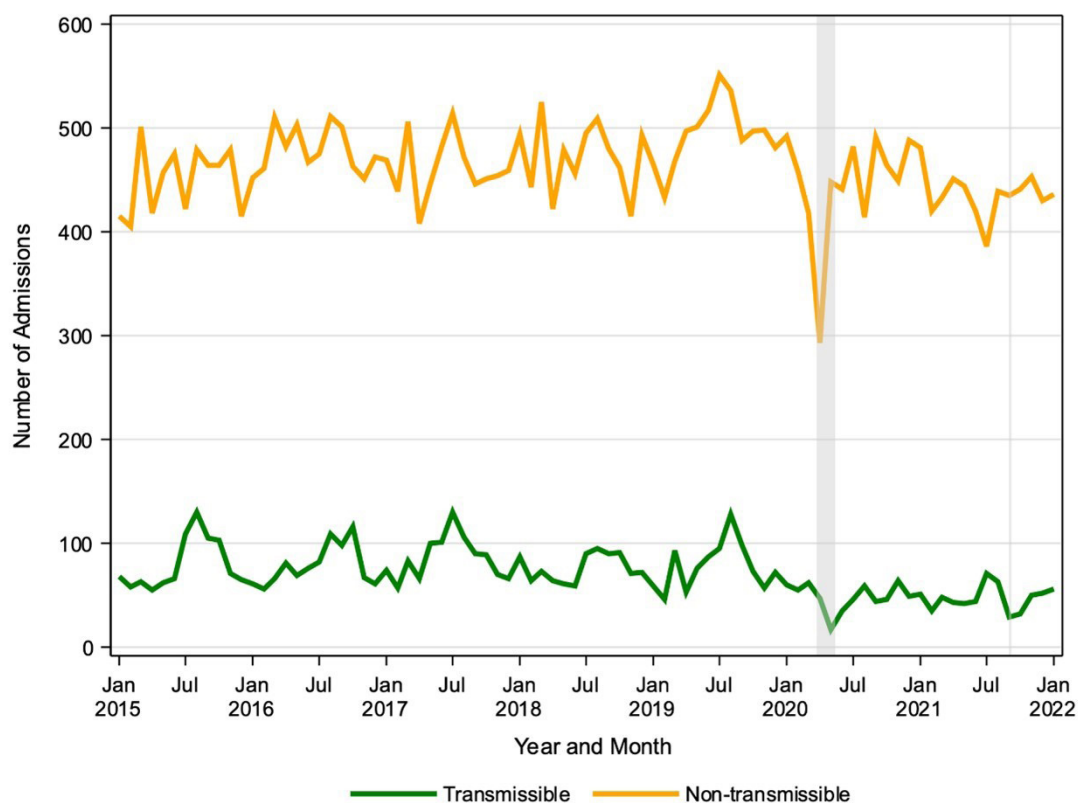
Table 1: Summary statistics for variables.

Variable	Overall N=47,407 (%)	Pre-lockdown N=34,581 (%)	2020 lockdown N=734 (%)	2021 lockdown N=105 (%)
Gender				
Female	26,293 (55.5)	19,325 (55.9)	404 (55.0)	56 (53.3)
Male	21,106 (44.5)	15,256 (44.1)	330 (45.0)	49 (46.67)
Ethnicity				
Māori	4,950 (10.4)	3,551 (10.3)	84 (11.4)	12 (11.4)
Pacific peoples	4,345 (9.2)	3,104 (9.0)	66 (9.0)	4 (3.8)
Other	38,112 (80.4)	27,926 (80.8)	584 (80.0)	89 (84.76)
Age				
16–64	16,623 (35.1)	12,040 (34.8)	247 (33.7)	35 (33.3)
≥65	30,784 (64.9)	22,541 (65.2)	487 (66.3)	70 (66.7)
Died inpatient	1,401 (3.0)	1,019 (2.9)	25 (3.4)	1 (1.0)
Living in a rest home	2,952 (6.2)	2,193 (6.3)	35 (4.8)	8 (7.6)
NZDep category				
Not deprived	29,433 (62.1)	21,367 (61.8)	460 (62.7)	72 (68.6)
Deprived	11,239 (23.7)	8,239 (23.8)	181 (24.7)	19 (18.1)
Very deprived	6,479 (13.7)	4,727 (13.7)	93 (12.7)	14 (13.3)
Missing	256 (0.5)	248 (0.7)	0 (0.0)	0 (0.0)
Transmissible disease	6,251 (13.2)	4,956 (14.3)	63 (8.6)	10 (9.5)

Table 2: Admission rates per 100,000 population for 2020 and 2021 lockdowns.

Classification	Pre-lockdown (baseline) Rate (95% CI)	2020 lockdown Rate (95% CI)	Rate ratio (95% CI)	P	2021 lockdown Rate (95% CI)	Rate ratio (95% CI)	P
Overall	24.08 (23.59–24.58)	17.16 (15.07–19.53)	0.71 (0.63–0.81)	<.0001	18.14 (12.63–26.04)	0.75 (0.52–1.08)	0.13
Transmissible	3.44 (3.33–3.56)	1.50 (1.14–1.96)	0.44 (0.33–0.57)	<.0001	1.66 (0.81–3.38)	0.48 (0.24–0.98)	0.004
Non-transmissible	20.69 (20.21–21.18)	15.97 (13.82–18.45)	0.77 (0.67–0.89)	0.0005	15.74 (10.48–23.64)	0.76 (0.51–1.14)	0.19

Figure 3: Admission rate ratios for the 2020 and 2021 lockdowns compared to pre-lockdown rates.
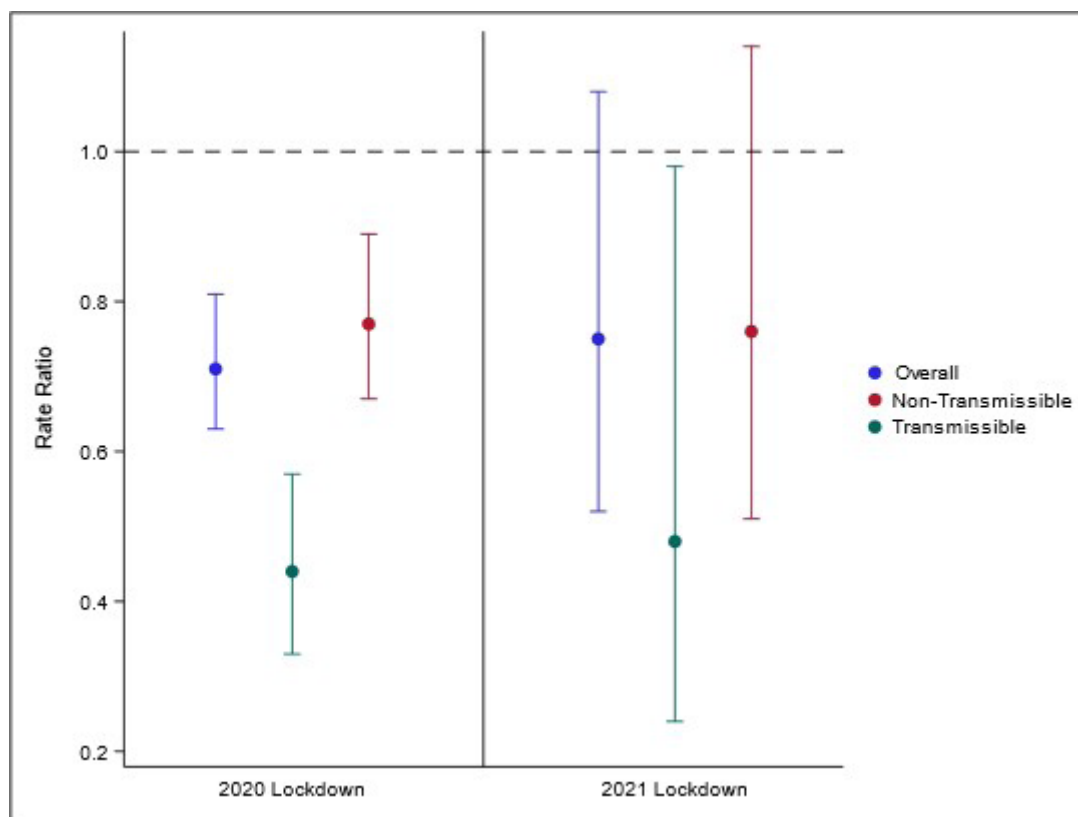
2020 lockdown, the much shorter duration and consequent lower number of admissions (n=735 versus n=105) made results frequently not statistically significant.

During the 2020 lockdown, rates of both transmissible and non-transmissible admissions to the WRH GMS were significantly lower than the pre-lockdown rates. Rate ratios were 0.71 and 0.44 respectively compared to pre-lockdown levels. While both decreased, the decrease in admissions due to transmissible diagnoses was significantly larger than that of non-transmissible diagnoses by a factor of 1.77.

We presume that the factors leading to the decrease in admissions for non-transmissible diseases (i.e., hospital avoidance or hospital diversion) would also have a similar impact on transmissible disease. The impact of public health measures on reducing admissions for transmissible illness is therefore best estimated by the transmissible admission rate *minus* the non-transmissible admission rate (0.71–0.44=0.36).

The imposition of lockdowns in Aotearoa New Zealand to control COVID-19 was effective.[14] Based on this study, they also significantly reduced hospital admissions for other transmissible diseases. However, admissions for transmissible diseases only accounted for 8.6% of analysed admissions during the 2020 lockdown and 14.4% of pre-2020 lockdown admissions.

The lockdowns also led to a significant reduction in admissions due to non-transmissible disease, which in absolute terms constitute most admissions to the WRH GMS. This is a potentially negative impact. We are not able to estimate the impact on mortality or morbidity of this reduction in hospital treatment from this dataset. While reports suggest that Aotearoa New Zealand did not experience any excess mortality during or in the time since the 2020 and 2021 lockdowns[14] it remains a reasonable concern that people may have experienced harm from not accessing appropriate care. It is possible, although beyond the scope of this study to assess, that hospital avoidance dominated hospital diversion given the very significant difficulties that primary care services also had operating under lockdown conditions. Further assessment of this potential impact, and how to ensure continued access to medical care despite lockdowns in a future pandemic, warrants further research.

Figure 4: Interaction plot for relative rate of transmissible and non-transmissible admissions during the 2020 lockdown compared to baseline by sub-group.
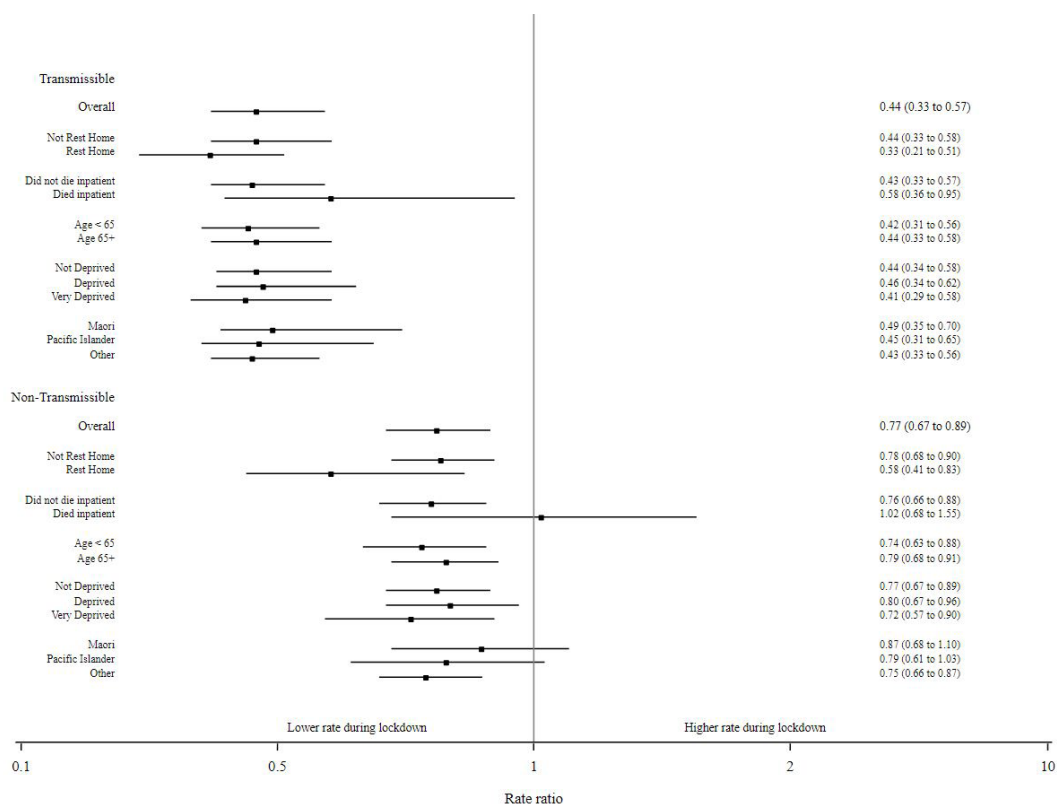

Figure 5: Transmissible admission rate per 100,000 population for fortnightly periods during and immediately after the 2020 lockdown.
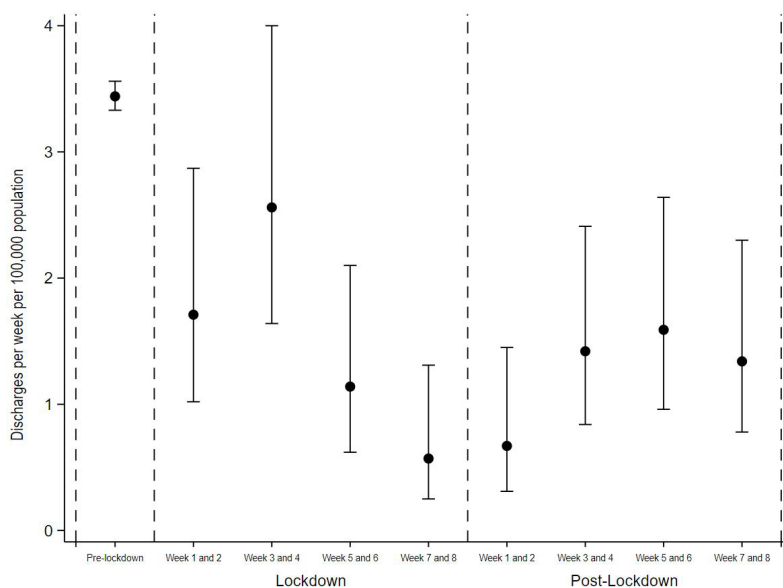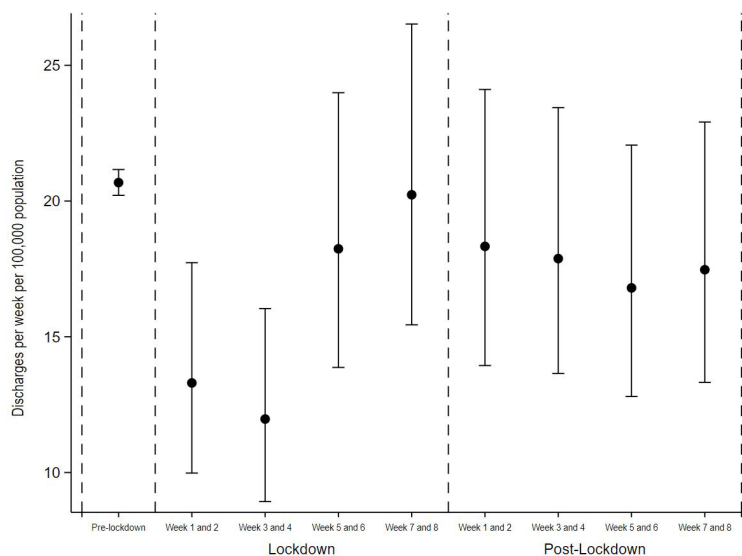
Figure 6: Non-transmissible admission rate per 100,000 population for fortnightly periods during and immediately after the 2020 lockdown.

Of the predefined sub-groups assessed, three findings are noteworthy. Firstly, the decrease in rate of admission for non-transmissible conditions appears to have been driven by the non-Māori and non-Pacific population, with rates not being statistically lower than pre-lockdown for either Māori or Pacific populations. Given existing barriers to Māori and Pacific populations in accessing health services,[15] this provides some reassurance that COVID-19 lockdowns did not further exacerbate inequities in access to hospital services.

Secondly, reductions in admission rates were similar across deprivation cohorts. This also supports the above finding that lockdowns did not exacerbate inequities that already exist in access to health services.

Thirdly, in respect to patients who died in hospital, there was no statistically significant reduction in overall admission rates. This suggests that the added difficulties of being present with dying relatives imposed by lockdown restrictions[16] did not affect admissions with palliative intent or outcome.

The time course of changes in transmissible and non-transmissible admission rates differed. Apart from the 2nd fortnight for transmissible diseases, the data conforms to our hypothesis, with:

- a gradual and sustained reduction in transmissible diseases. This suggests that there was a reduction in all transmissible conditions throughout the duration of the lockdown and beyond. With the Aotearoa New Zealand border remaining closed and the associated lack of introduction of new strains of transmissible diseases, such as seasonal influenza, disease transmission was considerably suppressed;

- an initial but short-lived reduction in non-transmissible diseases, which by week 5 was not significantly different from the baseline. Initially this decrease is likely to have been hospital avoidance, with the potential for hospital diversion measures, as they were introduced, to mitigate this over the following weeks, or for hospital avoidance itself to reduce.

The study has several limitations. This analysis only included data for patients presenting to WRH GMS. Caution is appropriate in applying these conclusions more generally to different services within WRH, or to the country more broadly. The study is based on an analysis of retrospectively coded data. This has inherent limitations. The categorisation of DRG diagnoses into transmissible or non-transmissible causes is somewhat arbitrary. Further, around 4.8% of admissions were uncoded, but these occurred consistently over the study period and showed no association with lockdown periods. Also, admissions were classified only on the primary

diagnosis, so may have omitted comorbid transmissible diagnoses. Postcode data were used to derive socio-economic status and therefore only approximate actual socio-economic status.

In summary, the biggest relative reduction in hospital admission over the two COVID-19 lockdowns was due to a reduction in transmissible illness, likely due to COVID-related public health measures. However, the biggest reduction in absolute terms was in non-transmissible illnesses, where hospital avoidance could potentially be associated with increased morbidity or mortality.

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REFERENCES
1. Birkmeyer JD, Barnato A, Birkmeyer N, et al. The Impact Of The COVID-19 Pandemic On Hospital Admissions In The United States. Health Aff (Millwood). 2020;39(11):2010-2017. doi: 10.1377/hlthaff.2020.00980.
2. Collyer TA, Athanasopoulos G, Srikanth V, et al. Impact of COVID-19 lockdowns on hospital presentations and admissions in the context of low community transmission: evidence from time series analysis in Melbourne, Australia. J Epidemiol Community Health. 2022;76(4):341-349. doi: 10.1136/jech-2021-217010.
3. Rennert-May E, Leal J, Thanh NX, et al. The impact of COVID-19 on hospital admissions and emergency department visits: A population-based study. PLoS One. 2021:16(6):e0252441. doi: 10.1371/journal.pone.0252441.
4. Shah SA, Brophy S, Kennedy J, et al. Impact of first UK COVID-19 lockdown on hospital admissions: Interrupted time series study of 32 million people. eClinicalMedicine. 2022;49:101462. https://doi.org/10.1016/j. eclinm.2022.101462 doi: 10.1016/j.eclinm.2022.101462.
5. Kapsner LA, Kampf MO, Seuchter SA, et al. Reduced Rate of Inpatient Hospital Admissions in 18 German University Hospitals During the COVID-19 Lockdown. Front Public Health. 2021;8:594117. doi: 10.3389/fpubh.2020.594117.
6. Bodilsen J, Nielsen PB, Søgaard M, et al. Hospital admission and mortality rates for non-covid diseases in Denmark during covid-19 pandemic: nationwide population based cohort study. BMJ. 2021;373:n1135. doi: 10.1136/bmj.n1135.
7. Department of the Prime Minister and Cabinet. COVID-19 Group [Internet]. 2023 [cited 2024 Feb 6]. Available from: https://covid19.govt.nz/about-our-covid-19-response/history-of-the-covid-19-alert-system/.
8. Arnetz BB, Goetz C, vanSchagen J, et al. Patient-reported factors associated with avoidance of in-person care during the COVID-19 pandemic: Results from a national survey. PLoS One. 2022;17(8):e0272609. doi: 10.1371/journal.pone.0272609.
9. Czeisler MÉ, Marynak K, Clarke KEN, et al. Delay or Avoidance of Medical Care Because of COVID-19-Related Concerns-United States. MMWR Morb Mortal Wkly Rep. 2020;69(36):1250-1257. http://dx.doi.org/10.15585/mmwr.mm6936a4.
10. Statistics New Zealand | Tatauranga Aotearoa. Infoshare: Estimated Resident Population for Regional Council Areas, at 30 June (1996+) [Internet]. 2021 [cited 2022 Oct 10]. Available from: https://infoshare.stats.govt.nz/.
11. Health New Zealand – Te Whatu Ora. Data references: Australian Refined Diagnosis Related Groups (AR-DRG) [Internet]. 2024 Feb [cited 2024 Jan 31]. Available from: https://www.tewhatuora.govt.nz/our-health-system/data-and-statistics/nz-health-statistics/data-references/.
12. Gardner W, Mulvey EP, Shaw EC. Regression analyses of counts and rates: Poisson, over-dispersed Poisson, and negative binomial models. Psychol Bull. 1995;118(3):392-404. doi: 10.1037/0033-2909.118.3.392.
13. Salmond CE, Crampton P. Development of New Zealand's deprivation index (NZDep) and its uptake as a national policy tool. Can J Public Health. 2012;103(8 Suppl. 2):S7-S11.
14. Kung S, Doppen M, Black M, et al. Reduced mortality in New Zealand during the COVID-19 pandemic. Lancet. 2021;397(10268):25. doi: 10.1016/S0140-6736(20)32647-7.
15. The Lancet. Tackling inequalities to improve wellbeing in New Zealand. Lancet. 2018;392(10144):254. doi: 10.1016/S0140-6736(18)31655-6.
16. Donnelly S, McDonald F, Goodyear C. Whānau experience of patients' deaths in Wellington Hospital during 2020 COVID-19 pandemic Levels 3 & 4. N Z Med J. 2022;135(1552):16-26.