Impact of Nonpharmaceutical Interventions on ICU Admissions During Lockdown for Coronavirus Disease 2019 in New Zealand—A Retrospective Cohort Study

Tobias P. Gonzenbach, MD[1]
Shay P. McGuinness, MB ChB[1,2,3]
Rachael L. Parke, RN, PhD[1–4]
Tobias M. Merz, MD[1]

OBJECTIVES: Nonpharmaceutical interventions are implemented internationally to mitigate the spread of severe acute respiratory syndrome coronavirus 2 with the aim to reduce coronavirus disease 2019–related deaths and to protect the health system, particularly intensive care facilities from being overwhelmed. The aim of this study is to describe the impact of nonpharmaceutical interventions on ICU admissions of non–coronavirus disease 2019–related patients.

DESIGN: Retrospective cohort study.

SETTING: Analysis of all reported adult patient admissions to New Zealand ICUs during Level 3 and Level 4 lockdown restrictions from March 23, to May 13, 2020, in comparison with equivalent periods from 5 previous years (2015–2019).

SUBJECTS: Twelve-thousand one-hundred ninety-two ICU admissions during the time periods of interest were identified.

MEASUREMENTS: Patient data were obtained from the Australian and New Zealand Intensive Care Society Adult Patient Database, Australian and New Zealand Intensive Care Society critical care resources registry, and Statistics New Zealand. Study variables included patient baseline characteristics and ICU resource use.

MAIN RESULTS: Nonpharmaceutical interventions in New Zealand were associated with a 39.1% decrease in ICU admission rates ($p < 0.0001$). Both elective (–44.2%) and acute (–36.5%) ICU admissions were significantly reduced when compared with the average of the previous 5 years (both $p < 0.0001$). ICU occupancy decreased from a mean of 64.3% (2015–2019) to 39.8% in 2020. Case mix, ICU resource use per patient, and ICU and hospital mortality remained unchanged.

CONCLUSIONS: The institution of nonpharmaceutical interventions was associated with a significant decrease in elective and acute ICU admissions and ICU resource use. These findings may help hospitals and health authorities planning for surge capacities and elective surgery management in future pandemics.

KEY WORDS: cohort studies; coronavirus disease 2019; health services; intensive care units; New Zealand; pandemics

The coronavirus disease 2019 (COVID-19) pandemic has created an unprecedented surge in hospitalizations and ICU admissions in most healthcare systems. In response, many governments have implemented nonpharmaceutical interventions (NPIs) aiming at suppressing transmission of severe acute respiratory syndrome coronavirus 2. These include enforcing social distancing by restricting gathering sizes and travel and isolation of positive cases and close contacts. NPIs do effectively moderate the spread of COVID-19

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(1) and prevent hospitals and ICUs from being overwhelmed by large numbers of patients.

It is conceivable that NPIs may influence the prevalence of hospitalizations for other causes than COVID-19. For the planning of critical care capacity when accounting for a surge in patients, it is important to understand the effect of NPIs on the number of patients needing ICU admission for any cause, be it COVID-19 related or not.

New Zealand introduced border restrictions and a four-level alert system of defined NPIs in mid-March 2020 (see Box) (2–4). On March 23, 2020, early after the detection of community transmission, the government imposed strict measures according to alert levels 3 and 4 to minimize nonessential social contacts other than with immediate family members for a period of 52 days. Analysis of anonymized mobile phone data (5) shows that these NPIs had a profound effect on the population's behavior and mobility. The last case of community transmission in the first wave was detected mid-May 2020, and during the following 101 days, no further cases were reported (6, 7).

In preparation for a pandemic-related surge in patients and in the context of low per capita ICU bed capacity in New Zealand, hospitals instituted an immediate reduction in elective surgery, particularly for conditions that would require an ICU admission. However, during the first wave of COVID-19 in New Zealand, only 95 COVID-19 patients were admitted to hospitals of which only 18 needed ICU-level care. Although hospitals developed criteria for triaging ICU admissions, these did not have to be implemented.

Consequently, we aimed to assess the effect of strict NPIs on characteristics and resource utilization of ICU admissions without the confounding element of a high COVID-19 patient load.

METHODS

Study Design and Population

We conducted a retrospective observational cohort study of all reported patient admissions to New Zealand ICUs during the alert levels 3 and 4 lockdown restrictions from March 23, 13:40, to May 13, 23:59, 2020. ICU admissions during the equivalent calendar periods from the 5 previous years (2015–2019) served as comparators.

Data Sources and Variables

Patient data were obtained from the Australian and New Zealand Intensive Society (ANZICS) Adult Patient Database (8, 9) run by the Centre for Outcome and Resource Evaluation (CORE) (10), accounting for more than 90% of all admissions to ICUs in New Zealand. These data are collected and entered at individual sites by trained data collectors and submitted on a quarterly basis via the CORE Portal. Additional data related to ICU resources were obtained from the ANZICS critical care resources registry (11). Population and mortality data were retrieved from Statistics New Zealand (12).

Patient data were stratified according to acuity into acute and elective admissions. Elective admissions are defined as elective surgical cases admitted to ICU from operating theater (OT) only (or from the OT at another hospital). Elective surgery is defined as surgery which can be delayed for more than 24 hours (8). Patient characteristics include age, sex, Acute Physiology and Chronic Health Evaluation (APACHE) III score and length of stay (LOS), APACHE III diagnostic groups (cardiovascular, respiratory, gastrointestinal, neurologic, sepsis, trauma, metabolic, hematologic, renal/genitourinary, and musculoskeletal/skin), and predefined subgroups (heart failure/cardiogenic shock, myocardial infarction/cardiac arrest, respiratory infections, and stroke/intracranial hemorrhage).

Ethics

The study protocol was assessed by the Health and Disability Ethics Committees (HDEC), Ministry of Health, New Zealand. The need for HDEC review was waived due to the observational nature of the analyzed deidentified patient data.

STATISTICS

Data are presented as numbers, percentages, and means with 95% CIs, as appropriate. Where applicable, numbers are reported per capita (million) to correct for the population growth in New Zealand during the observation period 2015–2020. Fisher exact and chi-square with Yates correction tests were used to compare patient characteristics of years 2015–2019 versus 2020. One-way analysis of variance with Tukey multiple comparison tests was used to compare differences in daily ICU admission numbers between years. Results are reported as f-value and significance value. ICU occupancy was calculated by the sum of LOS in ICU hours plus 1 hour per patient (to allow for bed space preparation) divided by the total of available beds × 24 (hr) × 52 (d). For ventilated patients with missing data for ventilation hours, the average ventilation duration from the same year was imputed. Ventilation data from 2015 to 2018 were not used (more than 20% not coded). Given the large database (> 10,000 ICU admissions analyzed) and to more closely align clinical and statistical significance, a two-sided p value of 0.01 was used to indicate statistical significance. Data were analyzed using GraphPad Prism 9.0.0 for Windows (GraphPad Software, San Diego, CA).

RESULTS

ICU Services New Zealand

During 2015–2019, an average of 180 (177–185) ICU beds were available (fully staffed and funded) in 18 different ICUs in New Zealand. In 2020, there were 185 available beds for a population of 5,013,550 people (36.9 ICU beds per million).

ICU Admissions

We identified a total of 12,192 ICU patient admissions during the time periods of interest (March 23, 13:40 until May 13, 23:59 during years 2015–2020). Two thirds of these admissions were acute (8,129), one third elective (4,063). The total number of ICU admissions per capita decreased by 39.1% during lockdown in 2020 compared with the mean of the same calendar periods of the 5 previous years 2015–2019 (**Table 1** and **Fig. 1*A***). Accordingly, the number of daily admissions differed significantly between the 6 analyzed year periods ($F = 20.47$; $p < 0.0001$). Pairwise comparisons indicated significant differences (all $p < 0.0001$) in daily admission numbers between all years from 2015 to 2019 versus 2020, whereas all other year comparisons were not significant (p range from 0.0321 to > 0.9999).

Similarly, the number of acute ICU admissions per capita in 2020 was 36.5% lower than the mean of the previous years (2015–2019) (Table 1 and **Fig. 1*B***). The number of daily acute admissions differed significantly during the 6 reported years ($F = 33.57$; $p < 0.0001$). Pairwise comparisons of acute daily admission numbers indicated significant differences for all years 2015 to 2019 versus 2020 (all $p < 0.0001$). All other comparisons were not significant (p range from 0.3756 to > 0.9999).

Elective admissions during the lockdown period in 2020 decreased by 44.2% compared with the mean of the same calendar periods of the 5 previous years 2015–2019 (Table 1 and **Fig. 1*C***). Pairwise comparisons of elective admissions between the years 2015–2020 are confounded by the unequal distribution of nonworking days (weekends, public holidays) and were therefore not performed.

ICU Resource Utilization

ICU occupancy decreased by 39.8% from 64.3% to 38.7% ($p = 0.0006$) (Table 1). There was no difference in the LOS ($p = 0.4230$) (Table 1). Average ventilation hours per patient decreased by 17.1% from 2019 to 2020 (data from previous years are incomplete) (Table 1).

Patient Characteristics

Patient characteristics (age, age distribution, sex), severity of illness (APACHE III score), and mortality outcomes (ICU, hospital) of patients admitted during the observed period in 2020 did not differ significantly (all $p > 0.01$) from equivalent time periods 2015–2019 (**Table 2**). The number of admissions for specific diagnostic groups and predefined subgroups were reduced proportionally across the board (Table 2).

Population Mortality

The number of deaths of all causes per capita in New Zealand during the lockdown period of 2020 did not differ from the mean number reported from the respective time periods of 2015–2019 ($\chi^2 = 1.353$; $p = 0.2448$).

DISCUSSION

In this nationwide retrospective cohort study, we observed a significant reduction in ICU admissions and ICU resource use associated with the implementation of NPIs in New Zealand during the first COVID-19 wave.

TABLE 1.
ICU Admissions and ICU Resource Utilization

ICU Admissions and Resource Utilization	2015	2016	2017	2018	2019	2020	p
Total admissions per capita (million)	456.3	505.8	441.9	439.3	432.6	277.0	< 0.0001
Acute admission (%)	293.1 (64.2)	314.1 (62.1)	256.5 (67.1)	292.3 (66.5)	312.7 (72.3)	191.5 (69.1)	< 0.0001
Elective admission (%)	163.2 (35.8)	191.6 (37.9)	145.4 (32.9)	147.1 (33.5)	119.9 (27.7)	85.6 (30.9)	< 0.0001
ICU occupancy (%)	61.7	69.5	62.5	65.9	62.1	38.7	0.0006
Length of stay, mean (95% CI), hr	67 (61–72)	64 (59–69)	65 (60–70)	68 (62–73)	67 (62–71)	64 (58–69)	0.85
Ventilation hours total (per patient)					50,678 (58.9)	27,443 (48.8)	
% of patients ventilated					40.5	40.5	

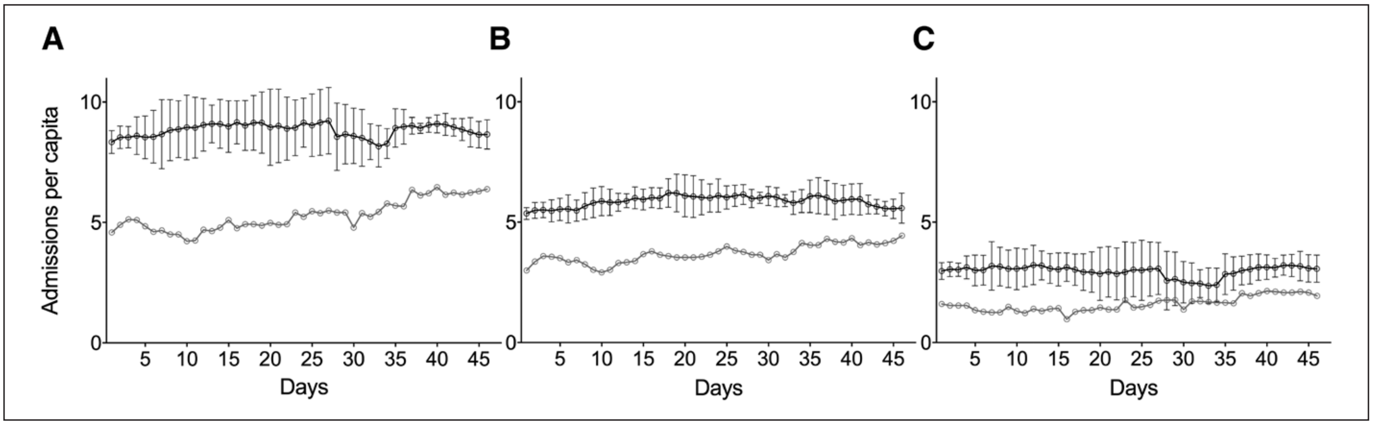

Figure 1. Seven-day moving average of daily ICU admissions per capita (million) of total (**A**), acute (**B**), and elective (**C**) admissions during the 52 d period of New Zealand coronavirus disease 2019 lockdown. *Gray data points* indicate admission numbers in 2020. Mean admission numbers from comparator periods from the years 2015 to 2019 are in *black* (*whiskers* indicate upper/lower boundary of 95% CI).

The 44.2% reduction in elective ICU admissions is likely to be attributed to the widespread cancellation of elective surgery requiring postoperative ICU care during the lockdown period, although this cannot be determined directly from the available data.

The 36.5% reduction in acute ICU admissions is unexpected and was observed to be proportional across all diagnostic groups and predefined subgroups. It is conceivable that some health disorders are reduced as a direct consequence of the established NPIs. Infectious diseases such as viral infections are less likely to be transmitted in the context of strict social distancing, and in fact, cases of influenza in New Zealand were at an all-time low during the lockdown (13). Stay-at-home orders and the closing of workplaces are likely to decrease the risk of trauma (14) associated with recreational activities and motor vehicle or occupational accidents. Lower hospitalizations for myocardial infarctions and cardiac arrests were previously reported in New Zealand (15) and other countries (16, 17). Whether these findings represent a true decline in the prevalence of acute coronary syndromes or are indicative of undertreatment remains speculative. Our lower numbers for neurologic, respiratory, gastrointestinal, and gynecologic/obstetric ICU admissions are more difficult to explain. Other authors have reported similar reductions in emergency presentations of neurologic (18, 19), respiratory (13, 16), gastrointestinal (20),

TABLE 2.
Patient Characteristics

Patient Characteristics	2015	2016	2017	2018	2019	2020	*p*
Age, mean (95% CI), yr	57 (57–58)	57 (56–58)	56 (55–57)	57 (56–58)	57 (56–58)	58 (57–59)	0.21
≤ 44, *n* (%)	498 (23.9)	546 (23.1)	538 (25.6)	524 (24.7)	528 (24.8)	328 (23.6)	0.55
45–64, *n* (%)	644 (30.8)	787 (33.3)	665 (31.6)	684 (32.2)	673 (31.7)	465 (33.5)	0.27
65–84, *n* (%)	860 (41.2)	945 (40)	816 (38.8)	856 (40.3)	859 (40.4)	558 (40.2)	0.98
≥ 85, *n* (%)	86 (4.1)	84 (3.6)	84 (4.0)	60 (2.8)	65 (3.1)	38 (2.7)	0.16
Male sex %	60	59	60	60	60	59	0.47
Acute Physiologic Assessment and Chronic Health Evaluation III score, mean (95% CI)	56 (55–58)	54 (53–55)	56 (55–57)	56 (55–57)	55 (53–56)	55 (53–57)	0.02
ICU mortality, %	8.1	5.9	7.3	7.6	7.5	6.0	0.68
Hospital mortality, %	11.3	8.6	9.9	10.6	10.5	8.0	0.96
Diagnostic groups per capita million, *n* (%)							
Cardiovascular	145.9 (32.0)	160.0 (31.6)	143.7 (32.5)	144.2 (32.8)	134.4 (31.1)	84.0 (30.3)	0.63
Respiratory	62.5 (13.7)	67.9 (13.4)	59.7 (13.5)	54.4 (12.4)	60.5 (14.0)	37.1 (13.4)	1.00
Gastrointestinal	61.8 (13.5)	69.2 (13.7)	50.9 (11.5)	55.0 (12.5)	47.4 (11.0)	33.9 (12.2)	0.16
Neurologic	37.3 (8.2)	45.6 (9.0)	36.4 (8.2)	42.4 (9.7)	39.3 (9.1)	25.5 (9.2)	0.74
Sepsis	38.5 (8.3)	38.5 (7.6)	38.0 (8.6)	35.0 (8.0)	36.4 (8.4)	29.1 (10.5)	0.21
Trauma	31.5 (6.9)	34.0 (6.7)	30.7 (6.9)	28.1 (6.4)	36.2 (8.4)	16.2 (5.8)	0.53
Metabolic	23.8 (5.2)	30.2 (6.0)	23.3 (5.3)	28.3 (6.5)	39.9 (6.9)	21.9 (7.9)	0.19
Hematologic	1.1 (0.2)	1.5 (0.3)	1.3 (0.3)	1.7 (0.4)	1.0 (0.2)	0.8 (0.3)	0.60
Renal/genitourinary	12.7 (2.8)	15.4 (3.0)	14.9 (3.4)	15.7 (3.6)	15.7 (3.6)	12.0 (4.3)	0.38
Musculoskeletal/skin	19.2 (4.2)	21.6 (4.3)	17.7 (4.0)	18.4 (4.2)	17.5 (4.0)	8.8 (3.2)	0.63
Gynecologic	4.1 (0.9)	5.4 (1.1)	5.9 (1.3)	5.4 (1.2)	5.7 (1.3)	4.2 (1.5)	0.77
No diagnosis	18.3 (4.0)	16.5 (3.3)	19.5 (4.4)	10.8 (2.4)	8.6 (2.0)	3.6 (1.3)	0.14
Diagnostic subgroups per capita million, *n* (%)							
Heart failure/cardiogenic shock	6.3 (1.4)	7.7 (1.5)	6.1 (1.4)	5.6 (1.3)	8.3 (1.9)	3.8 (1.4)	1.00
Myocardial infarction/cardiac arrest	15.3 (3.3)	15.0 (3.0)	20.0 (4.5)	19.6 (4.5)	19.1 (4.4)	8.8 (3.2)	0.74
Respiratory infections	10.5 (2.3)	15.0 (3.0)	14.1 (3.2)	10.5 (2.4)	18.9 (4.4)	8.0 (2.9)	1.00
Stroke/intracranial hemorrhage	16.2 (3.5)	16.1 (3.2)	16.6 (3.8)	18.6 (4.2)	20.2 (4.7)	10.8 (3.9)	0.36
Gynecologic/obstetric	4.4 (1.0)	5.8 (1.1)	6.9 (1.6)	6.6 (1.5)	6.3 (1.5)	4.4 (1.6)	0.79

and obstetrical/gynecologic (21, 22) patients during lockdown. It has been suggested that this effect may be explained by changes in patients' behavior (16, 18–21) following the public stay-at-home advice due to the fear to contract COVID-19 in hospitals and the reluctance to put more pressure on already overworked nurses and doctors. However, in New Zealand, the number of COVID-19 patients in hospitals was very low, and there were no media reports of an overstretched hospital system. To date, a total of 127 COVID-19 patients were admitted to hospital in New Zealand of which only 18 needed ICU-level care (23).

The decrease in acute ICU admissions during the lockdown period with virtually unchanged diagnostic group ratios raises concerns that a substantial number of critically ill patients did not receive necessary ICU-level treatment. We would expect that any undertreatment would be reflected in higher mortality, leading to an increase in excess mortality, as was the international experience during the COVID-19 pandemic (24). In contrast, the mean weekly death rate in New Zealand did not increase during the immediate lockdown period, and mortality fell by 11% below historical rates in the months thereafter (25). This makes it unlikely that relevant undertreatment of critically ill patients explains the lower number of ICU admission during lockdown.

As a consequence of an overall 39.1% reduction in ICU admissions to New Zealand ICUs and an unchanged mean LOS during the lockdown period, ICU occupancy declined by 39.8%. In hindsight, our findings raise the question of whether the extent of reduction of elective surgery was reasonable (in absolute numbers, an estimated 340 cases were deferred during the 52 d period). We observed a trend toward more elective admissions over the course of the New Zealand lockdown period. Nevertheless, in the context of persistently low COVID-19 case rates, low ICU occupancy would have allowed for more elective cases to go ahead. Our findings support the idea of establishing a national network (26) providing up-do-date information about hospital and ICU capacities to help hospitals and health authorities planning for surge capacities and elective surgery management in future pandemics.

Although our study is based on a large and well-curated international ICU database and includes the vast majority of admissions to New Zealand ICUs in the respective time periods, there are several study limitations. The retrospective design does not allow for establishing a causal link between COVID-19 NPIs and the observed changes in admission rates and characteristics. It is therefore uncertain if such effects would be observed during a future pandemic

COVID-19 RESTRICTIONS IN NEW ZEALAND (2, 4)

Level 1: During uncontrolled COVID-19 pandemic overseas, New Zealand remains in alert level 1. Sporadic imported cases and isolated transmission could be occurring in New Zealand. The range of measures includes border entry measures to minimize the risk of importing COVID-19 cases and intensive testing for COVID-19 and rapid contact tracing. Self-isolation and quarantine may be required. There are no restrictions on personal movement within New Zealand. Use of masks is mandatory on all public transports including bus, train, ferries, and domestic flights.

Level 2: If active clusters are present in more than one region and limited community transmission occurs, New Zealand moves to alert level 2. Physical distancing is encouraged, and socializing in groups up to 100 is possible. Hospitality businesses keep customers separated and served by a single person. Schools and universities remain open. Mask wearing is mandatory in public transport.

Level 3: With multiple active clusters in multiple regions and multiple community transmission cases, New Zealand moves to alert level 3. People are instructed to stay home in their bubble other than for essential personal movement, including going to work, school, or local recreation. Early childhood care and schools remain open, but children should learn at home if possible. People must work from home unless this is not possible. Businesses other than supermarkets, pharmacies, petrol stations, or hardware stores cannot offer services that involve close personal contact. Gatherings of up to 10 people are allowed but only for weddings and funerals. Interregional travel is minimal. Hospitals may defer non-urgent services or treatments. Use of masks is mandatory in public transport and highly recommended in closed spaces where physical distancing is not always possible.

Level 4: With sustained and intensive community transmission and widespread outbreaks, New Zealand moves to alert level 4. People are instructed to stay home in their bubble other than for essential personal movement. Travel is severely limited. All gatherings are cancelled, and public venues closed. All businesses remain closed except for essential services (e.g., supermarkets, pharmacies, clinics, petrol stations) and lifeline utilities. Educational facilities are closed. According to the National Response Framework, healthcare services are reprioritized, and only urgent acute care is conducted. Routine care is postponed and elective procedures may be deferred. Not many people will need to wear masks because only those delivering or accessing essential services will be allowed freedom of movement. It is highly recommended to wear a mask in closed spaces where physical distancing is not always possible and contact with other people outside the bubble may occur.

implementing similar NPIs. However, although admissions per capita showed a slow trend for decrease for the respective time periods from 2015 to 2019, the reduction of admissions in 2020 was substantial and highly significant. We cannot identify any other plausible cause than the established national NPIs to explain this effect. Second, we cannot ascertain that our findings are generalizable to healthcare systems outside of New Zealand. Finally, the source data were not complete for all evaluated parameters.

In conclusion, we report a substantial decrease in acute and elective ICU admissions during the New Zealand lockdown. Patient numbers were lower in all admission diagnosis groups, which led to a marked decrease in ICU resource utilization. The causes for the unexpected reduction in acute ICU admissions remain conjectural and cannot be determined from our data. However, possible reluctance to present in hospitals out of fear from contracting COVID-19 demands for good public health communication, emphasizing the importance of prompt an appropriate care in case of medical emergencies.

Our findings support the establishment of a national ICU capacity information system providing real-time data regarding ICU capacity. This would help to optimize ICU admission management to minimize reductions in elective surgery throughput in similar scenarios. Last, pandemic-related public health resource prediction models (27–37) should take into account that non–COVID-19 patient numbers may decline during lockdown periods.

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1 Cardiothoracic and Vascular ICU (CVICU), Auckland City Hospital, Auckland, New Zealand.

2 Medical Research Institute of New Zealand, Wellington, New Zealand.

3 ANZIC-Research Centre, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC, Australia.

4 School of Nursing, Faculty of Medical and Health Sciences, The University of Auckland, Auckland, New Zealand.

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Address requests for reprints to: Tobias Gonzenbach, MD, Auckland City Hospital, CVICU, 2 Park Road, Grafton, Auckland 1023, New Zealand. E-mail: tobiasg@adhb.govt.nz

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