

Royal New Zealand College of General Practitioners:
Research and Education Committee (REC)
Final Report

Defining catchment boundaries and their populations for Aotearoa New Zealand's rural hospitals

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Sharing our research:

Our research was presented at the national Rural Health Conference Sept 9, 2022, Christchurch (Defining rural NZ hospital catchment boundaries and their populations (25 mins), Dr Jesse Whitehead).

We will deposit this final report in 'Our Archives' the University of Otago research archives, <https://ourarchive.otago.ac.nz>

We have included key tables and figures in this report. Supplementary tables are available on request.

We plan to submit a manuscript to the Journal of Primary Health Care.

Summary:

Our study findings provide, for the first time for Aotearoa New Zealand, a standardised description of each rural hospital's catchment boundary and the socio-demographic characteristics of the population living within this area. Our results highlight the considerable heterogeneity in the populations served by rural hospitals, both in size and sociodemographic characteristics.

Using this platform, further research can now be undertaken to address questions such as: What is the extent to which NZ rural hospitals improve access to healthcare, improve health outcomes and improve health equity for rural communities, particularly for Māori and Pacific peoples?

Introduction

New Zealand (NZ) residents of rural areas have poorer health outcomes than those living in urban areas, and this is accentuated for Māori.¹ It is estimated that around 10-15% of New Zealanders rely on rural hospitals for health care.²

International studies have identified rural hospitals as important providers of healthcare which can benefit the health of rural populations by enhancing access to, and integration of, services, however definitions of rural hospitals are varied and highly country-contingent.³⁻⁵ The extent to which NZ rural hospitals improve access to healthcare, improve health outcomes and improve health equity for rural communities, particularly for Māori and Pacific peoples, is currently unknown.

There is very limited NZ rural hospital research to inform better health delivery. Much of the research is now out of date, and there is no formally recognised definition or up-to-date Ministry of Health list of rural hospitals. Furthermore, there is considerable variation in the size, structure and resources of rural hospitals (including access and integration within the wider healthcare system, governance, workforce models and level and range of diagnostic services offered).⁶ These factors have not been recently quantified and their effects on health care outcomes are poorly understood.⁷ Importantly, there is no standardised description of each rural hospital's catchment boundary and the characteristics of the population living within this area.

The working definition of rural hospitals accepted by the Medical Council of New Zealand and the Royal New Zealand College of General Practitioners' Division of Rural Hospital Medicine (DRHMNZ) for purposes of the Rural Hospital Medicine training programme includes: geographical distance from specialist services; acute in-patient bed capacity; 24/7 acute care; and a predominantly generalist workforce. The DRHMNZ list of rural hospitals currently sits at 24.2

Internationally, various approaches have been used to define health service catchments including distance or travel time measures, and the mapping of utilisation patterns.^{8,9} In NZ, general practice catchments have been developed using patient enrolment records.¹⁰ This information was also used to measure the distances that patients travelled and thereby estimate likely catchment areas for other general practice services where patient enrolment data was unavailable. However, this geographic approach may not be directly transferable to the development of rural hospital catchments. It is likely that actual patterns of rural hospital utilisation are different from general practice, and from assumed geographic catchments. International research indicates that patients often bypass their closest health services for a variety of reasons.¹¹ Previous NZ research has shown that general practice patients do not always use their closest provider.¹² There are also likely to be differences in rural hospital utilisation patterns that reflect multiple factors, including patient preferences, their relationships with providers, and the rural hospital variations mentioned above.

The lack of a consistent and fit-for-purpose rurality classification for health research in NZ has likely masked the existence of rural-urban health inequities. Recently, a novel Geographic Classification for Health (GCH) for use in NZ health research has been developed designed to accurately monitor urban-rural variation in health outcomes and access to health services in NZ.¹³

New Zealand collects a wealth of health data, including major Ministry of Health administrative datasets, disease specific registries and primary care (PHO) data. This data can be used to determine health outcomes and health service utilisation for given populations, including, potentially, those served by a rural hospital. However, before this routinely collected health data can be used to examine outcomes for rural hospitals, the catchments of NZs rural hospitals need to

be defined using the same small geographic units (e.g: domiciles and SA1s) at which health and census data is provided. Defining rural hospital catchments will also improve the ability of hospitals and funders to understand the sociodemographic characteristics of the population that is served by, and is likely to use, rural hospitals. This would include developing a better understanding of the age structure, ethnic profile, and socioeconomic position of populations served by rural hospitals, as well as using the GCH to understand the rurality (and/or remoteness) of such populations.

The aim of this study was to define and describe a catchment population for each of New Zealand's rural hospitals.

Methods

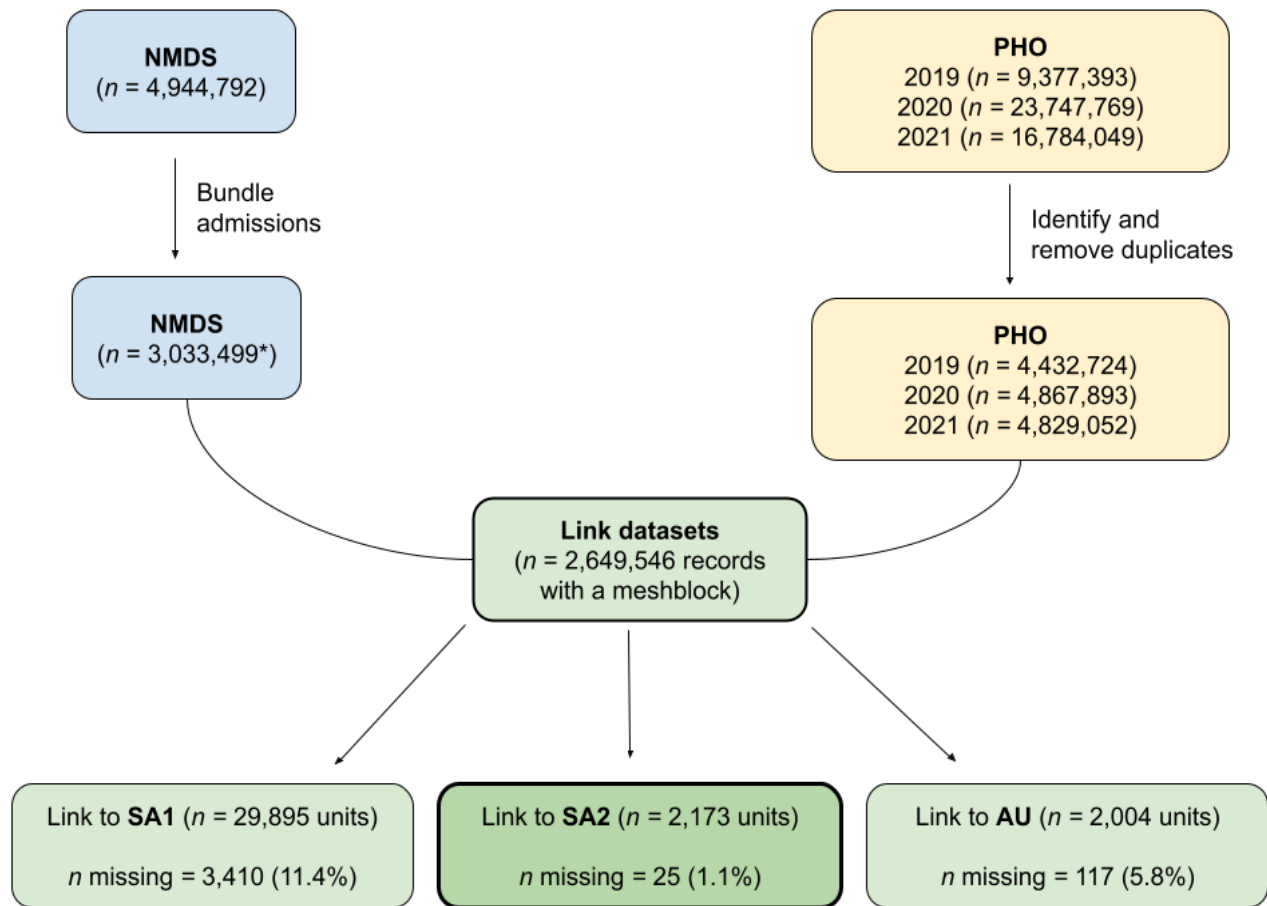
Data

The exploratory nature of this research meant that a large number of datasets were required. These included health datasets collected and provided by the Ministry of Health, population datasets based on census data, and geographic datasets which were used to support analysis. The first health dataset provided by the Ministry of Health came from the National Minimum Dataset (NMDS) and included anonymised information on all public hospital discharges between 01/01/2017 and 29/10/2019. This dataset included information on the hospital of admission, date of admission, date of discharge, domicile of residence, and a unique encrypted NHI number. Anonymised Primary Health Organisation (PHO) datasets for 2019, 2020 and 2021 were also provided. The PHO dataset includes information on all people registered with a primary health organisation, and importantly provides residential information to a smaller geographic unit - the meshblock level. All data was anonymised and included a unique encrypted NHI number which allowed linkage to the hospital discharge dataset. Population datasets were later linked to the rural hospital catchments in order to develop population profiles for each catchment. This census-based data was downloaded from the Statistics New Zealand data service 'NZ.Stat', and included '*Age and sex by ethnic group (grouped total responses), for census usually resident population counts, 2006, 2013, and 2018 Censuses (RC, TA, SA2, DHB)*' and '*Statistical area 2 population projections by age and sex 2018 (base)- 2043*'. Additional datasets used to support the development of population profiles for each rural hospital catchment included the Geographic Classification for Health ¹ a novel rurality classification for health research, and the New Zealand Index of Socioeconomic Deprivation.¹⁴ Several datasets with geographic information were accessed to support this analysis. These included: (1) all hospital locations, defined as rural hospitals using the DRHMNZ definition and list of rural hospitals (n=24) ², from the Ministry of Health Facility code table which also noted the 'facility code' of each hospital¹⁵; (2) geographic units (SA1, SA2, Area Unit 2017) from Statistics New Zealand (2022)¹⁶; (3) the Geographic Areas file 2020, a concordance file allowing various geographic units to be linked (Statistics New Zealand, 2020)¹⁷; (4) the Land Information New Zealand (2022) NZ Street address dataset ¹⁸, which allowed address-weighted SA1s to be created; and (5) a road network layer that allows for drive times between locations to be estimated.¹⁹

Data cleaning and linkage

The process by which data was cleaned and linked is illustrated in *Figure 1*. First, an R script was written to 'bundle' together admissions related to a unique NHI that occurred within 24 hours of each other and are more likely to represent patient transfers than novel hospitalisations. Next, duplicate NHI records in each of the three PHO datasets were identified and removed. To assign a

meshblock to each hospital discharge, the NMDS was linked iteratively with the three PHO datasets, beginning with the most recent 2021 dataset. Any NMDS records that were unable to be linked to a meshblock were then linked to the 2020 PHO dataset, and then finally the 2019 PHO dataset. In this way a total of 2,649,546 hospital discharge records were assigned a meshblock to represent the individual's residential location. The final stage of linking involved using the Geographic Areas concordance file to link meshblocks to other administrative geographies such as SA1s and SA2s. Since domiciles align with Area Units (AU) discharge records were able to be directly linked using the same concordance file. The completeness of this linking varied by geographic unit and resulted in different levels of 'missingness'. For instance, 11% of SA1s could not be linked to hospital discharge records via meshblock, while 6% of AUs were unable to be linked via domicile code. SA2s had relatively high levels of completeness, with only 25 SA2s unable to be linked to hospital discharge records, reflecting 1% of all SA2s.



* Includes 2,104,450 admissions where the NHI number appears more than once

Figure 1: Data cleaning and linkage process

Analytic approach

Two exploratory approaches to developing rural hospital catchments were tested: (1) catchments based on the drive-time from each SA1 to the nearest hospital; and (2) catchments based on the number of hospital discharges in an area. Although a key limitation of both of these approaches is the lack of in-depth qualitative analysis to ground truth findings, such analysis was beyond the scope of the current project.

Drive time approach

The drive-time approach is based on an assumption that people will use the hospital closest to their residential address. It involved using Geographic Information Systems (GIS) to estimate the drive time from each address-weighted SA1 to the nearest hospital. Address-weighted SA1s were created using the NZ Addresses dataset, and provide a more accurate representation of the 'population' centre of administrative units than the 'geographic' centre does. This is particularly true for rural administrative units which tend to be much larger, but often have population centres close to the boundaries. SA1s which had a rural hospital as the closest hospital were identified, and these areas defined the 'drive-time' catchments for each rural hospital.

Hospital discharge approach

The hospital discharge approach to developing catchments recognises that people do not always use their closest health service.^{12,20} Administrative health data can be used to develop health service catchments that reflect actual service use rather than assumed catchments based on proximity to services.^{10,21,22} To undertake this approach administrative health data was first cleaned and linked to SA1s, SA2s, and AUs as outlined above. Due to the variation in data completeness (see Supplementary Table 3, S3) and additional benefits for using SA2s within this study context as outlined in Supplementary Table 2 (S2), it was decided that SA2s would be used as the primary geographic unit to map and define hospital-discharge based rural hospital catchments. Since many health datasets are still only available at the domicile, it was decided that maps at this level of administrative unit would also be produced.

Hospital discharges were split by hospital and separately aggregated to SA2 and AU. Each rural hospital was grouped into three categories based on the total volume of hospital discharges across the study period: Large (>10,000), Medium (100-10,000), and Small (<100). A sensitivity analysis was used to test different potential thresholds – the minimum number of discharges for an area to be included within a rural hospital catchment – for each of the categories. It was determined that the most stable, consistent, and robust thresholds would be 10 for hospitals with a small volume of discharges (<100), 50 for hospitals with less than 10,000 discharges, and 100 for hospitals with 10,000 or more discharges across the period.

The next step was to use these thresholds to identify SA2s and domiciles that would be included within each rural hospital catchment. The approach taken was to identify the 'external' boundary of a catchment, as there were some cases where areas within the centre of a catchment did not meet the threshold for hospitalisations but were surrounded by other areas that did meet the threshold. There were two reasons that catchments were developed at both SA2 and Domicile code level. The

first is that these geographic units allow rural hospital catchments to be utilised for different purposes with the available health and population data. SA2s can be linked to readily available census data from Stats NZ, and domiciles are more easily able to be used when aggregating health data, such as hospital discharges or deaths. While we have outlined an approach by which such data could be linked to an alternative geographic unit, this is likely to be impractical in many instances. The second reason that both SA2s and domiciles were used to define rural hospital catchments is to bring attention to the geographic inconsistencies within routinely collected health and population datasets, in the hope that data interoperability can be improved.

Finally, census usually resident population data was linked to the SA2 catchments of each rural hospital. This was combined with SA2-level GCH rurality category, and NZDep2018 area-based socioeconomic deprivation to develop socio-demographic profiles of the population within each rural hospital catchment. The results presented in the following section are based on SA2-level catchments

Results

Two exploratory approaches to developing rural hospital catchments were investigated. It was determined that a drive-time based approach (based on an assumption that people would use their closest hospital) would not accurately reflect the reality of rural hospital service utilisation. Therefore, the hospital discharge approach was used to develop catchments at the SA2 level. *Figure 2* displays areas that fall within one of the 24 rural hospital catchments identified in this study. It should be noted that these are exploratory and preliminary catchments only, and we do not suggest that these should be used for funding or resource allocation purposes. *Figure 2* indicates that several rural hospital catchments in Northland, the Central North Island, the West Coast, and the Southern region of New Zealand overlap and/or border onto each other.

Figure 3 below displays the drive-time based catchment for Dunstan hospital overlaid onto hospital discharge catchments developed at the SA2 and domicile levels. *Figure 3* highlights that the actual pattern of hospitalisations differs from that which might be expected using a drive-time approach alone, and also displays the differences between catchments defined at the SA2 and domicile level. The domicile-based catchment includes a substantial area to the north of Wanaka which is not present in the SA2 catchment, while the SA2-based catchment extends further to the east of Cromwell and west of Wanaka.

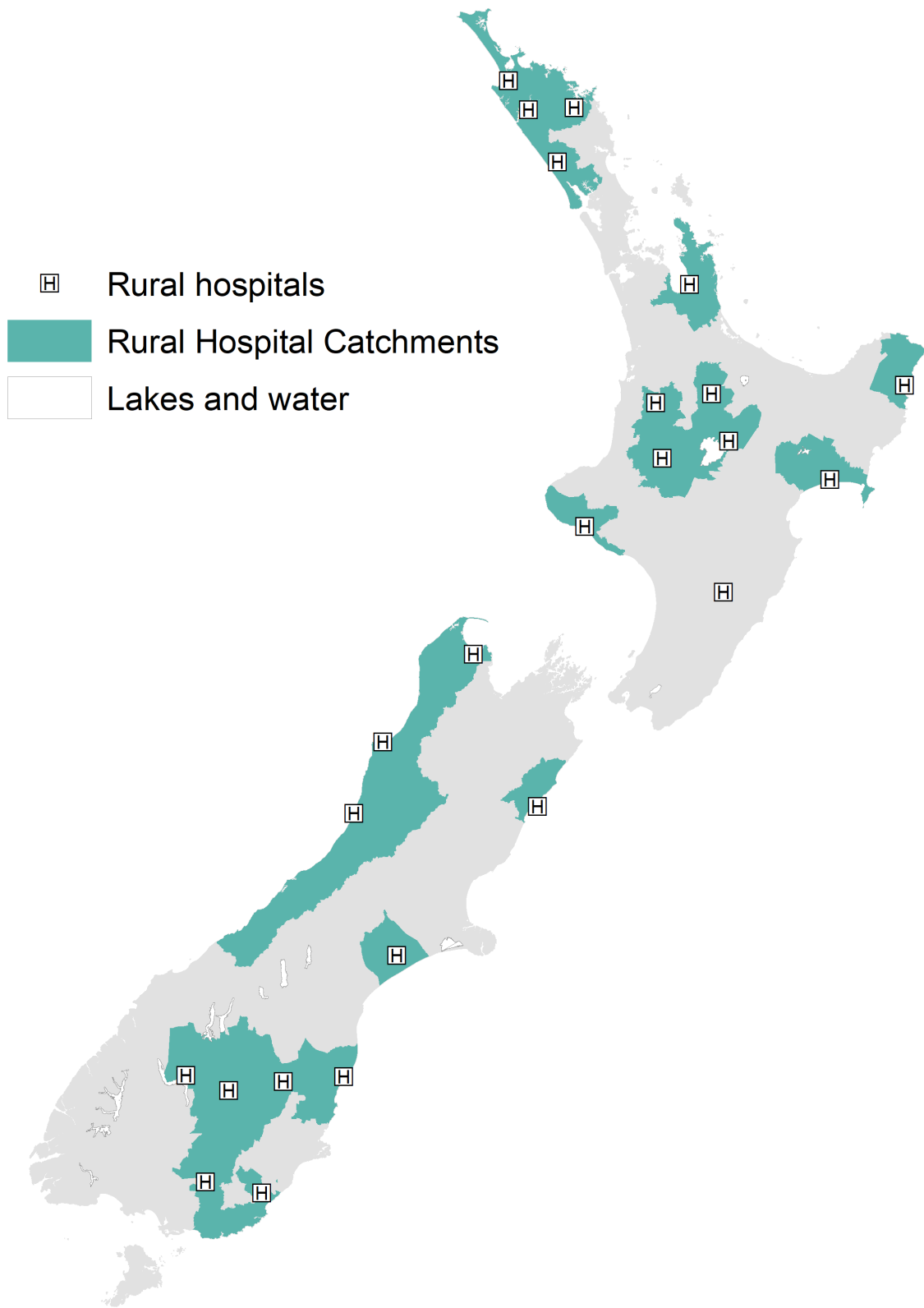


Figure 2: Exploratory rural hospital catchments

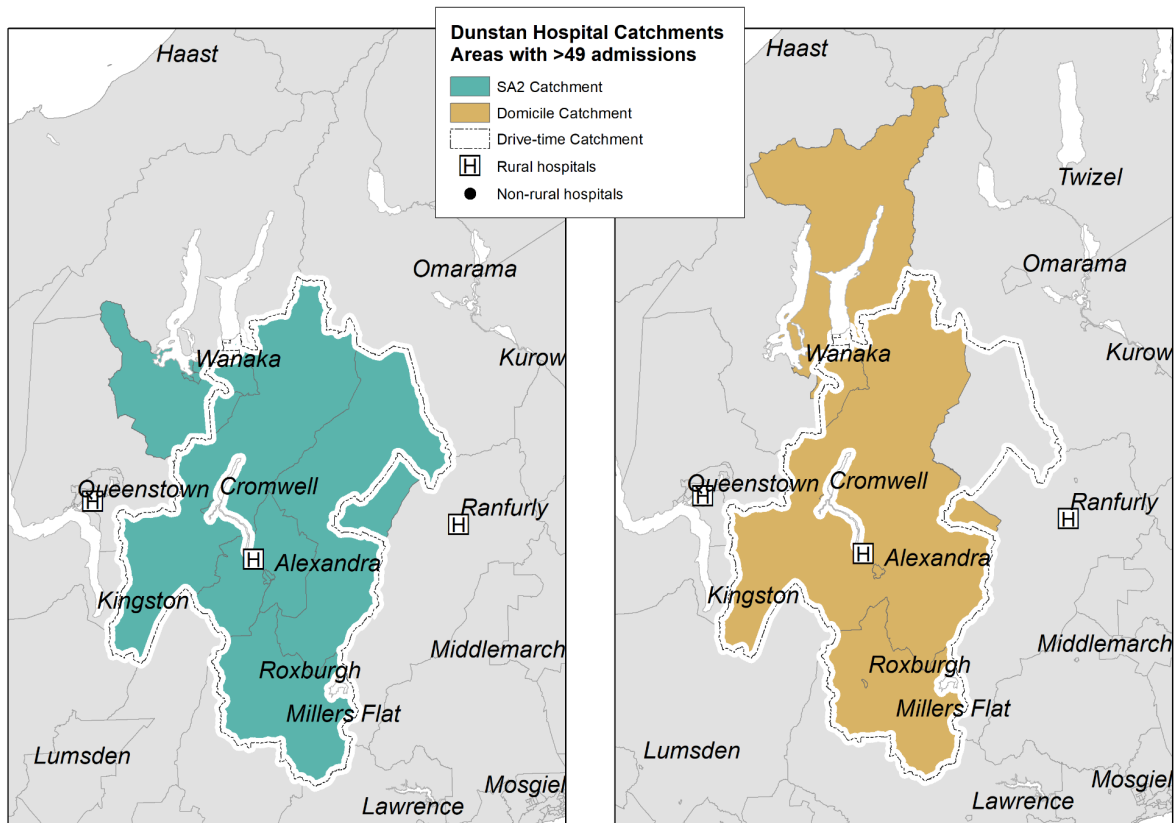


Figure 3: Differences between the drive-time based catchment and hospital discharged based catchments at the SA2 and domicile level for Dunstan Hospital

Tables 1 – 4 below display key information about the population residing within each of the 24 rural hospital catchments defined at the SA2 level in this study.

Table 1 includes the total number of admissions for each hospital during the period. It also uses the Census 2018 usually resident population to show the estimated total catchment population for each catchment, which is disaggregated by ethnicity and broad age groups. It is important to note that ethnicity data from the census is not prioritised, meaning that individuals can indicate that they identify with more than one ethnicity, and therefore the combination of total responses for each ethnic group can be more than the total catchment population.

Table 2 displays additional socioeconomic information about each rural hospital catchment population using NZDep2018 – grouped into quintiles. Q1 reflects people who live in neighbourhoods that are among the wealthiest 20% of all neighbourhoods in NZ. Conversely, Q5 represents people living in neighbourhoods that are among the most socioeconomically deprived of all neighbourhoods in NZ. Table 2 suggests that there are quite substantial differences in the

socioeconomic profiles of different rural hospital catchment populations, with some hospitals serving populations that live in very socioeconomically deprived areas, and others serving populations that are much wealthier. *Table 2* also incorporates the GCH to display the number of people within each rural hospital catchment that live within each of the five GCH categories. U1 and U2 refer to 'urban' areas of NZ, and none of the 24 catchments incorporated any urban populations. R1, R2, and R3 are rural areas of NZ, with R3 being the most remote and R1 reflecting rural areas that are closer to cities. This information in *Table 2* also highlights substantial variation in the profile of populations served by rural hospitals.

Table 3 shows the Māori and Pacific populations of each rural hospital catchment, further disaggregated by broad age groups (under 15 years, 15-29 years, 30-64 years, 65 years and older).

Table 4 outlines selected population projections for each rural hospital catchment, including the projected 2033 total catchment population, the size and proportion of the projected population aged 65 years and older in 2033, and the size and proportion of the population projected to be living in areas of high socioeconomic deprivation by 2033.

Additional sociodemographic information, including broad age groups for each ethnicity, is available as a supplementary file on request (S1).

Table 1: Demographic data (census 2018 usually resident population) for each rural hospital catchment

Name	Number of admissions during period	Total Catchment Population	Māori	Pacific	European	Asian	Other	Under 15	Aged 15-29	Aged 30-64	Over 65
Thames Hospital	26,417	57,564	11,562	1,515	49,467	2,133	975	9,807	7,683	24,474	15,588
Te Nikau Grey Hospital	18,012	31,308	3,657	468	28,353	1,053	744	5,577	4,893	14,709	6,141
Kaitaia Hospital	12,549	28,299	14,817	1,440	17,955	768	438	6,267	4,392	12,288	5,337
Taupo Hospital	11,253	38,613	11,520	1,239	29,571	1,878	693	8,088	6,363	16,992	7,167
Ashburton Hospital	8,466	33,330	2,727	1,716	27,927	2,457	768	6,804	5,919	14,649	5,970
Bay of Islands Hospital	8,315	39,087	16,743	1,680	26,205	1,215	609	8,265	6,258	16,980	7,584
Hawera Hospital	7,418	34,137	8,646	690	28,161	1,119	588	7,560	5,907	14,988	5,661
Oamaru Hospital	7,051	22,641	1,878	855	19,809	1,323	405	4,194	3,423	9,993	5,025
Tokoroa Hospital	6,740	26,436	8,343	2,523	16,947	1,086	372	5,523	4,458	10,200	3,849
Dunstan Hospital	5,839	32,568	2,373	546	30,114	996	708	5,709	4,782	15,504	6,591
Lakes District Hospital	4,871	25,308	1,287	327	19,842	3,333	1,986	3,990	6,969	12,396	1,944
Dargaville Hospital	3,366	14,433	4,146	621	11,607	396	222	2,832	2,289	6,240	3,072
Te Kuiti Community Hospital	3,062	13,128	5,394	435	8,793	582	177	2,982	2,502	5,577	2,076
Taumarunui Community Hospital	2,830	8,040	3,486	213	5,547	240	114	1,719	1,341	3,513	1,473
Gore Hospital	2,624	17,454	2,142	192	15,708	522	267	3,513	2,910	7,800	3,222
Buller Health	2,578	7,272	825	120	6,696	159	156	1,212	891	3,381	1,779
Hokianga Health - Rawene Clinic	2,052	6,123	4,137	375	2,901	120	51	1,377	903	2,622	1,218
Wairoa Hospital & Health Centre	1,959	8,370	5,499	279	3,972	189	90	1,962	1,503	3,465	1,431
Clutha Health First	1,394	10,743	1,344	255	9,432	453	189	2,001	1,827	4,884	2,034
Kaikoura Hospital	1,147	3,912	723	30	3,363	162	108	633	600	1,851	834
Dannevirke Community Hospital	434	5,508	1,824	129	4,140	216	39	1,137	978	2,166	1,233
Maniototo Health Services	344	1,635	156	12	1,485	81	18	279	228	726	339
Te Whare Hauora O Ngati Porou - Te Puia Springs	232	3,576	3,216	123	918	36	30	903	612	1,518	540
Golden Bay Community Health	54	5,226	420	45	4,962	108	117	882	624	2,556	1,167

Table 2: Socioeconomic and rurality data for each rural hospital catchment

Name	NZDep18 Q1	NZDep18 Q2	NZDep18 Q3	NZDep18 Q4	NZDep18 Q5	GCH U1	GCH U2	GCH R1	GCH R2	GCH R3
Thames Hospital	1,464	4,170	15,882	14,631	21,417			16,365	40,740	459
Te Nikau Grey Hospital	1,332	2,457	7,719	9,072	10,728			15,732	13,146	2,430
Kaitaia Hospital		2,133		4,380	21,786				14,577	13,722
Taupo Hospital	4,533	8,142	7,491	7,575	10,872			31,212	7,401	
Ashburton Hospital	7,512	11,997	6,891	6,930				27,888	5,442	
Bay of Islands Hospital		8,472	4,710	5,625	20,280			7,047	28,449	3,591
Hawera Hospital		1,734	7,131	11,319	13,953			17,994	16,143	
Oamaru Hospital	1,050	4,689	8,937	7,671	294			21,654	987	
Tokoroa Hospital			6,153		20,283			24,045	2,391	
Dunstan Hospital	18,546	12,243	1,779						29,670	2,898
Lakes District Hospital	13,647	9,159	1,485					25,308		
Dargaville Hospital				3,513	10,920			6,594	7,839	
Te Kuiti Community Hospital			1,833	3,696	7,599			3,027	8,880	1,221
Taumarunui Community Hospital			1,050	2,283	4,707				5,970	2,070
Gore Hospital		8,238	6,144	1,443	1,629			3,825	13,629	
Buller Health			1,260		6,012				6,558	714
Hokianga Health - Rawene Clinic					6,123				1,095	5,028
Wairoa Hospital & Health Centre				861	7,509				8,370	
Clutha Health First		1,608	3,363	5,772				6,738	4,005	
Kaikoura Hospital		1,689	2,223						3,912	
Dannevirke Community Hospital				2,148	3,360				5,508	
Maniototo Health Services		1,635								1,635
Te Whare Hauora O Ngati Porou - Te Puia Springs					3,576				954	2,622
Golden Bay Community Health			5,226						5,226	

Table 3: Māori and Pacific populations, by broad age group, for each rural hospital catchment

Name	Māori <15 years	Māori 15-29	Māori 30-64	Māori 65+	Pacific <15 years	Pacific 15-29	Pacific 30-64	Pacific 65+
Thames Hospital	3708	2430	4368	1050	552	315	525	108
Te Nikau Grey Hospital	1152	786	1461	249	159	123	162	9
Kaitaia Hospital	4680	2961	5721	1467	663	318	381	69
Taupo Hospital	3699	2499	4443	870	477	324	375	54
Ashburton Hospital	1023	675	882	141	693	438	585	18
Bay of Islands Hospital	5232	3573	6498	1455	723	390	486	66
Hawera Hospital	2994	1926	3141	591	291	165	198	18
Oamaru Hospital	645	459	639	153	369	186	267	27
Tokoroa Hospital	3207	2223	3399	633	1167	741	1017	219
Dunstan Hospital	855	483	906	144	141	135	258	15
Lakes District Hospital	366	348	549	39	114	90	108	9
Dargaville Hospital	1293	900	1569	396	252	150	183	33
Te Kuiti Community Hospital	1611	1266	2079	432	189	105	123	15
Taumarunui Community Hospital	1092	762	1329	309	90	48	60	6
Gore Hospital	759	504	747	132	72	48	63	15
Buller Health	288	150	318	66	48	18	42	3
Hokianga Health - Rawene Clinic	1149	729	1665	597	195	66	96	18
Wairoa Hospital & Health Centre	1626	1158	2118	597	123	63	78	15
Clutha Health First	441	291	510	90	66	75	96	12
Kaikoura Hospital	228	144	297	54	6	15	15	0
Dannevirke Community Hospital	618	447	648	108	54	33	36	6
Maniototo Health Services	63	36	51	9	3	6	3	0
Te Whare Hauora O Ngati Porou - Te Puia Springs	870	591	1314	441	51	24	36	6
Golden Bay Community Health	120	81	180	42	12	12	15	6

Table 4: Selected 2023 population projections for each rural hospital catchment

Name	Total projected population 2033	Projected 65+ population 2033 (n)	Projected 65+ population 2033 %	Projected NZDep Q5 2033 (n)	Projected NZDep Q5 2033 %
Thames Hospital	64,310	23,490	36.5	23,870	37.1
Te Nikau Grey Hospital	32,190	9,580	29.8	10,680	33.2
Kaitaia Hospital	33,120	9,050	27.3	25,170	76.0
Taupo Hospital	44,380	11,790	26.6	11,970	27.0
Ashburton Hospital	38,650	8,480	21.9		
Bay of Islands Hospital	46,990	12,640	26.9	22,970	48.9
Hawera Hospital	36,990	8,550	23.1	14,840	40.1
Oamaru Hospital	24,830	7,040	28.4	320	1.3
Tokoroa Hospital	29,420	6,530	22.2	22,230	75.6
Dunstan Hospital	45,260	11,780	26.0		
Lakes District Hospital	37,250	4,400	11.8		
Dargaville Hospital	15,870	4,790	30.2	12,070	76.1
Te Kuiti Community Hospital	14,180	3,160	22.3	8,240	58.1
Taumarunui Community Hospital	8,190	2,180	26.6	4,830	59.0
Gore Hospital	18,240	4,630	25.4	1,690	9.3
Buller Health	7,110	2,520	35.4	5,900	83.0
Hokianga Health - Rawene Clinic	6,690	1,900	28.4	6,690	100.0
Wairoa Hospital & Health Centre	9,210	2,140	23.2	8,300	90.1
Clutha Health First	11,390	2,950	25.9		
Kaikoura Hospital	4,480	1,440	32.1		
Dannevirke Community Hospital	6,030	1,710	28.4	3,690	61.2
Maniototo Health Services	1,770	570	32.2		
Te Whare Hauora O Ngati Porou - Te Puia Springs	4,020	830	20.6	4,020	100.0
Golden Bay Community Health	5,840	2,050	35.1		

Discussion

Summary of principal findings

Our study findings provide, for the first time for Aotearoa New Zealand, a standardised description of each rural hospital's catchment boundary and the socio-demographic characteristics of the population living within this area. Our results highlight the considerable heterogeneity in the populations served by rural hospitals, both in size and sociodemographic characteristics. It is clear that NZ's rural hospitals serve very different communities.

Strengths and weaknesses of the study

One strength of this study is our ability to now, take a standardised approach to describing rural hospital catchments in NZ. This is a considerable improvement on previous ad hoc approaches to identifying populations served by rural hospitals. Our detailed methodology also improves the transparency of determining catchments. An additional strength of this study is that we took an exploratory approach that used both drive-time and hospital-admission approaches to developing catchments. While both of these approaches have their own strengths and weaknesses, our consideration of both methods means that our results are less likely to be systematically biased in a particular direction. Furthermore, research team members contributed considerable broad expertise which included detailed knowledge of the rural hospital context, which helped to make our results more meaningful. Nevertheless, the approach of the current study has been 'data-driven' and lacks any formal qualitative input.

We will seek opportunities to further refine the catchments with additional quantitative and qualitative data.

Meaning of the study: possible mechanisms and implications for clinicians and policy makers

Our results concur with previous findings that there is substantial variation in the size of facilities defined as a 'rural hospital' in Aotearoa New Zealand. The study findings mean that researchers and policy makers can now proceed to more meaningfully quantify variation in the structure and resources of rural hospitals. This may include access to rural hospitals, examinations of their integration within the wider healthcare system, governance models, workforce models, the level and range of diagnostic services offered, and how each of these align with community need.

Previously we have been unable to definitively identify particular communities served by rural hospitals. The study findings will further help to define the role delineation between different types of facilities and develop targets for access to services for rural communities.

The development of standardised rural hospital catchments also means that routinely collected health data can now be used to examine outcomes for the populations served by rural hospitals in NZ. Study findings will also permits a better comparison between NZ and international literature or international definitions.

Unanswered questions and future research

Using this platform further research can be undertaken to address questions such as:

- What is the extent to which NZ rural hospitals improve access to healthcare, improve health outcomes and improve health equity for rural communities, particularly for Māori and Pacific peoples?;
- What is the role of rural hospitals in the delivery of high quality, cost effective and equitable health care for people living in rural NZ;
- How and why does patient bypass behaviour interact with rural hospitals?

References

1. Crengle S, Davie G, Whitehead J, De Graaf B, Lawrenson R, Nixon G. Mortality outcomes and inequities experienced by rural Māori in Aotearoa New Zealand. *New Zealand Medical Journal*. 2022.
2. Royal New Zealand College of General Practitioners (RNZCGP). Division of Rural Hospital Medicine Training Programme Handbook. Wellington: RNZCGP; 2020
3. Pitchforth E, Nolte E, Corbett J, Miani C, Winpenny E, Van Teijlingen E, et al. Community hospitals and their services in the NHS: identifying transferable learning from international developments—scoping review, systematic review, country reports and case studies *Health Services and Delivery Research* 2017;5(19):1-220.
4. Nolte E, Corbett J, Fattore G, Kaunonen M, Miani C, Pitchforth E, et al. Understanding the role of community hospitals: an analysis of experiences in five countries: Ellen Nolte. *Eur J Public Health*. 2016;26(suppl1).
5. Vaughan L, Edwards N. The problems of smaller, rural and remote hospitals: Separating facts from fiction. *Future Healthcare Journal*. 2020;7(1):38.
6. Blattner K, Clay L, Miller R, Nixon G, Crengle S, Richard L, et al. New Zealand's rural hospitals in 2021: findings from an exploratory questionnaire survey. *Journal of Primary Health Care*. 2022.
7. Health and Disability System Review. Health and Disability System Review - Interim Report. Hauora Manaaki ki Aotearoa Whānui – Pūrongo mō Tēnei Wā. Wellington: HDSR; 2019.
8. Schuurman N, Fiedler RS, Grzybowski SC, Grund D. Defining rational hospital catchments for non-urban areas based on travel-time. *International journal of health geographics*. 2006;5(1):1-11.
9. Alegana VA, Khazenzi C, Akech SO, Snow RW. Estimating hospital catchments from in-patient admission records: a spatial statistical approach applied to malaria. *Scientific reports*. 2020;10(1):1-11.
10. Whitehead J, Pearson AL, Lawrenson R, Atatoa-Carr P. Defining general practitioner and population catchments for spatial equity studies using patient enrolment data in Waikato, New Zealand. *Applied Geography*. 2020;115:102137.
11. Jackson JE, Cope MR, Sanders SR, Pierce H. Privilege and Place: an exploratory study about healthcare bypass behavior. *Rural and Remote Health*. 2020;21(1):5952-.
12. Whitehead J, Pearson AL, Lawrenson R, Atatoa-Carr P. Spatial equity and realised access to healthcare—a geospatial analysis of general practitioner enrolments in Waikato, New Zealand. *Rural & Remote Health*. 2019;19(4).
13. Whitehead J, Davie G, de Graaf B, Crengle S, Fearnley D, Smith M, et al. Defining rural in Aotearoa New Zealand: a novel geographic classification for health purposes. *N Z Med J*. 2022;135(1559):24-40.
14. Atkinson J, Salmond C, Crampton P. NZDep2018 Index of Deprivation, Final Research Report. Wellington University of Otago 2019 December 2020.
15. Ministry of Health. (2022). Facility code table. <https://www.health.govt.nz/nz-health-statistics/data-references/code-tables/common-code-tables/facility-code-table>
16. Statistics New Zealand 2022. Geographic Data Service [Available from:<https://datafinder.stats.govt.nz/>].
17. Statistics New Zealand. (2020). Geographic areas file. <https://datafinder.stats.govt.nz/table/104285-geographic-areas-file-2020/data/>
18. Land Information NZ. (2022).NZ Street Address. [available from:<https://data.linz.govt.nz/layer/53353-nz-street-address/>].
19. Beere P. Creating a road network analysis layer with travel time estimates using open-source data. GeoHealth Laboratory, New Zealand, 2016.

20. Alford-Teaster J, Lange JM, Hubbard RA, Lee CI, Haas JS, Shi X, et al. Is the closest facility the one actually used? An assessment of travel time estimation based on mammography facilities. *International journal of health geographics*. 2016;15(1):1-10.
21. Sofianopoulou E, Rushton S, Rubin G, Pless-Mulloli T. Defining GP practice areas based on true service utilisation. *Health & place*. 2012;18(6):1248-54.
22. Panaretto KS, Dellit A, Hollins A, Wason G, Sidhom C, Chilcott K, et al. Understanding patient access patterns for primary health-care services for Aboriginal and Islander people in Queensland: a geospatial mapping approach. *Australian Journal of Primary Health*. 2017;23(1):37-45.