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The epidemiology of serious skin infections in New Zealand children: comparing the Tairawhiti region with national trends

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Abstract

Aim Serious skin infections are an increasing problem for New Zealand children with the highest national incidence in the Gisborne (Tairawhiti) region on the East Coast of New Zealand's North Island. This study aimed to describe the epidemiology of serious skin infections in children in this region, and make comparisons with equivalent national data to identify factors that might be contributing to elevated infection rates.

Methods Hospitalisation data were reviewed for 0–14-year-old children in the Tairawhiti region discharged from hospital with a serious skin infection between 1990 and 2007. A range of demographic variables were compared to equivalent data for New Zealand cases over the same period. The ratio of observed to expected discharges was calculated after indirectly standardising the Tairawhiti population age, ethnicity and deprivation composition to that of the total New Zealand population.

Results In Tairawhiti the age-adjusted incidence of serious skin infections increased from 641.1/100 000 in 1990–1999 to 988.4/100 000 in 2000–2007, while the New Zealand incidence increased from 354.3/100 000 to 531.7/100 000. Preschool-aged children, Māori children, and those living in deprived neighbourhoods had the highest infection rates in all regions. The disparity between Māori and non-Māori children was significantly greater in Tairawhiti than nationally. The standardised ratio of observed to expected discharges in Tairawhiti compared with New Zealand was 1.42 (95%CI 1.32–1.52) in 1990–1999 and 1.28 (95%CI 1.19–1.36) in 2000–2007.

Conclusions Serious skin infections are an increasing problem for all New Zealand children, but incidence rates in the Tairawhiti region are consistently greater than average national trends, with significantly larger ethnic disparities. The population composition of this region only partly accounts for the difference, suggesting the involvement of other unknown aetiological factors; these warrant further research.

Skin and subcutaneous tissue infections are a heterogeneous group of superficial bacterial infections, most commonly caused by opportunistic skin pathogens: *Staphylococcus aureus* and *Streptococcus pyogenes*.[1]

While these infections are usually effectively treated within the primary care setting, several international studies have recognised an increase in the number of cases serious enough to require hospitalisation.[2–4] This subset of more significant cases has been termed 'serious skin infections'.

In New Zealand (NZ) the increase has been particularly marked, with the rate of cellulitis double that of Australia and the United States of America.[5] Between the years 1990 and 2007 the national incidence rate almost doubled,[6,7] making these infections one of the most common reasons for childhood hospitalisation.[8]

Within NZ significant inter-regional variation in the incidence of serious skin infections has been noted; these differences are hypothesised to be multi-factorial and in part reflect the distribution of population groups who are known to experience higher disease rates, notably Māori and Pacific children, children from lower socioeconomic backgrounds, and children less than 5 years old.[5–10]

The Tairawhiti (Gisborne) region and District Health Board (DHB) is a geographically isolated area of 45 000 people on the East Coast of NZ's North Island. The region is unique for its warm climate, large Māori population (47.3% of the total population and 58.0% of the 0-14 year old population), youthfulness (26.2% of people are aged less than 15 years old),[11] and high level of deprivation (the region has the largest proportion of highly-deprived residents in the country).[12]

In Tairawhiti, skin infections present a major challenge in both primary and secondary level care; recent research by the authors found that between 1990 and 2007 Tairawhiti District Health had the highest incidence of childhood serious skin infections out of all NZ DHBs.[6]

This study aimed to describe the incidence and epidemiology of serious skin infections in children in the Tairawhiti region over the period 1990–2007, to compare these local patterns to equivalent national data, and to determine whether the infection incidence observed in the Tairawhiti region is greater than that which is expected given the 'high-risk' population composition.

Methods

Case selection and data extraction—Hospital discharge data were obtained from the NZ Ministry of Health for all children aged 0-14 years, admitted at least overnight to a NZ public hospital between 1 January 1990 and 31 December 2007, with a principal or additional discharge diagnosis from a defined list of serious skin infection International Classification of Disease (ICD) codes (see Appendix 1 at the end of this article). Cases after July 1999 were identified using ICD-10 diagnostic codes, and cases prior to this date by ICD-9 codes which were forward and backward mapped from ICD-10.

This case definition was developed in recent work which found the validity of the former definition was markedly improved by including categories of skin infections previously overlooked in epidemiological analyses. With the addition of skin infections of atypical anatomical sites, those secondary to either primary skin disease or trauma, and those recorded as additional diagnoses (see Appendix), the sensitivity of the case definition increased from 61.0% to 98.9% with little loss in specificity.[13]

Each discharge record included a unique patient identifier (encrypted National Health Index number) enabling transfers and readmissions within 30 days with the same principal diagnosis code to be removed. To ensure a better match with the census population, overseas visitors were excluded. Day cases were excluded from the case definition due to inconsistencies in the recording of these events between regions and over time.

Patient variables including age, prioritised ethnicity, gender and home domicile code and admission variables such as the season, year, DHB, duration and outcome of admission were recorded and collated. Due to the small numbers of Pacific and other non-Māori ethnic groups in the Tairawhiti region, prioritised ethnicity used only two categories, Māori and non-Māori, with non-Māori including NZ European, Pacific, Asian and all other non-Māori ethnic groups.

Assigning levels of socioeconomic deprivation used the New Zealand Deprivation Index (NZDep) and was based on the home domicile census area units (CAUs) of cases. The NZDep is based on nine variables extracted from census data;[14] NZDep 1 indicates least deprivation and 10 indicates highest deprivation. In 2.21% of cases domicile codes could not be linked to CAUs due to retired codes and addresses outside of classification.

To reduce the impact of these 'missing CAUs', retired domicile codes were linked to new codes using files from the Ministry of Health and Statistics NZ (R. Bishop, Statistics New Zealand, personal communication; CAU changes 1991-2006, Wellington, 2009; C. Lewis, New Zealand Health Information Service, personal communication; Domicile code mapping, Wellington, 2009).

Data analysis—The data were analysed using Microsoft Excel® and SAS®. Denominators in rate calculations were derived from usually resident population counts from the 1991, 1996, 2001, and 2006 censuses. Counts from each census were used to approximate the population in the preceding and subsequent two years. Age adjustment used the World Health Organisation (WHO) standard population. Trends between populations were explored by the calculation of rate ratios (RRs) with 95% confidence intervals (95% CIs) calculated using the log-transformation method.[15] Significant differences in RRs were indicated by a two-tailed p-value <0.05.

Indirect standardisation—The final part of this analysis used indirect standardisation to adjust for variables in the Tairawhiti population that could affect disease rates, and hence establish whether the observed incidence (or crude incidence) of serious skin infections in the region was in line with the incidence expected after taking into account the high-risk age, ethnicity and deprivation composition of the population.

Typically, direct standardisation is used to validly compare two or more groups that differ in health determinants, however this method requires a large population to ensure age, deprivation and ethnicity-specific rates remain stable. Due to the small numbers in some subgroups in the Tairawhiti population, direct standardisation could not be used.

Age/ethnicity/deprivation-specific rates were calculated using interpolated usually resident population counts by CAU from the 1991, 1996, 2001, and 2006 censuses. Indirect standardisation was used to standardise each variable, both individually and in combination, across two time periods (1990–1999 and 2000-2007) with NZ in total (including Tairawhiti) used as the standard population. Expected discharge numbers for each age/ethnicity/deprivation group were calculated by multiplying the national rates for that stratum by the usually resident population for that stratum in the Tairawhiti region. Five cases with unknown deprivation scores were excluded from this analysis.

The ratio of observed to expected (O:E) cases was then calculated. An O:E of '1' denoted the observed number of discharges was the same as the expected number, an O:E less than '1' indicated the observed number was less than the expected number and conversely an O:E greater than '1' indicated the observed number was greater than the expected number. Statistical significance was determined by calculating 95% confidence intervals for these ratios.

Results

Selection of cases, incidence and impact—In the Tairawhiti region a total of 1976 hospitalisations met the case definition. From this total, 10 (0.5%) overseas visitors, 50 (2.5%) transfers, 166 (8.4%) day cases, and 39 (2.0%) readmissions were excluded. This left 1711 (86.6%) cases of childhood serious skin infection for further analysis. Of these cases, 1 patient was reported to have been discharged dead from hospital (case fatality of 0.06%). Hospitalisation data recorded a total of 6459 hospital days over the study period. The median and mean lengths of stay were 2 and 3.8 days respectively.

In New Zealand during the same period there were a total of 82 408 hospitalisations which met the case definition. From this, 213 (0.3%) private hospital admissions, 955 (1.2%) overseas visitors, 3109 (3.8%) transfers, 12 353 (15.0%) day cases, and 1210 (1.5%) readmissions were excluded. Of the remaining 64 568 cases, 29 were reported to have been discharged dead from hospital (case fatality 0.04%). Hospitalisation data recorded a total of 213 141 hospital days over the study period. The mean and median lengths of stay were 2 and 3.3 respectively.

Table 1 shows the incidence of childhood serious skin infections in both the Tairawhiti region and NZ during 1990–1999 (ICD-9) and 2000-2007 (ICD-10). As recommended by the previous work developing the case definition, these data are disaggregated by category and level of diagnosis.[13] During the earlier time period, 1990–1999, the age-adjusted total incidence of infections in Tairawhiti was 641.1/100 000 while the total NZ incidence was slightly over half this rate at 354.3/100 000.

By 2000–2007 the incidence in Tairawhiti had increased by over 50% to 988.4/100 000, while that in NZ had increased by a similar proportion to 531.7/100,000. A more detailed version of this table is provided in the Appendix.

Table 1. The incidence of serious skin infections in children aged 0-14 years in Tairawhiti and NZ, disaggregated by category and level of diagnosis, between 1990–1999 (ICD-9) and 2000–2007 (ICD-10)

Category	Level of diagnosis	Tairawhiti region				New Zealand			
		1990–1999		2000–2007		1990–1999		2000–2007	
		No.†	Rate‡	No.†	Rate‡	No.†	Rate‡	No.†	Rate‡
Serious skin infections of typical sites (previously used case definition)	Principal All level	352 456	284.5 368.5	431 580	453.8 610.7	13541 17074	166.3 209.7	18177 24086	264.9 351.0
Serious skin infections of atypical anatomical sites	Principal All level	72 100	58.2 80.8	37 45	39.0 47.4	3170 5233	38.9 64.3	1866 2270	27.2 33.1
Serious skin infections secondary to primary skin disease	Principal All level	81 194	65.5 156.8	82 212	86.3 223.2	1406 5364	17.3 65.9	1909 6170	27.8 89.9
Serious skin infections secondary to external trauma	Principal All level	25 48	20.2 38.8	15 76	15.8 80.0	635 1270	7.8 15.6	420 3101	6.1 45.2
Crude total serious skin infections	Principal All level	530 798	428.3 644.9	565 913	594.9 961.4	18752 28941	230.3 355.4	22372 35627	326.0 519.2
Age-adjusted total serious skin infections	All level		641.1		988.4		354.3		531.7

ICD: international classification of disease.

†Total number of cases during time period.

‡Average annual incidence per 100 000 (based on usually resident population counts from NZ Census).

Incidence by year and season, 1990–2007—Figures 1 and 2 illustrate the incidence of serious skin infections in the Tairawhiti region and in the whole of NZ during each of the 18 years studied. Results are presented for incidence by category and in total. Between the years 1990 and 2007 the incidence of infections more than doubled in the Tairawhiti region (from 423.6/100 000 in 1990 to 952.6/100 000 in 2007), while the NZ incidence increased by just under double (from 298.0/100 000 to 547.3/100 000).

In both settings the increasing infection incidence was a direct reflection of increases in the incidence of serious skin infections of typical sites, along with a small contribution from infections secondary to primary skin trauma. Infections secondary to primary skin disease increased less, and those of atypical sites declined over this period.

Figure 1. The incidence of serious skin infections in 0–14-year-old children in the Tairawhiti region by category and year, 1990–2007

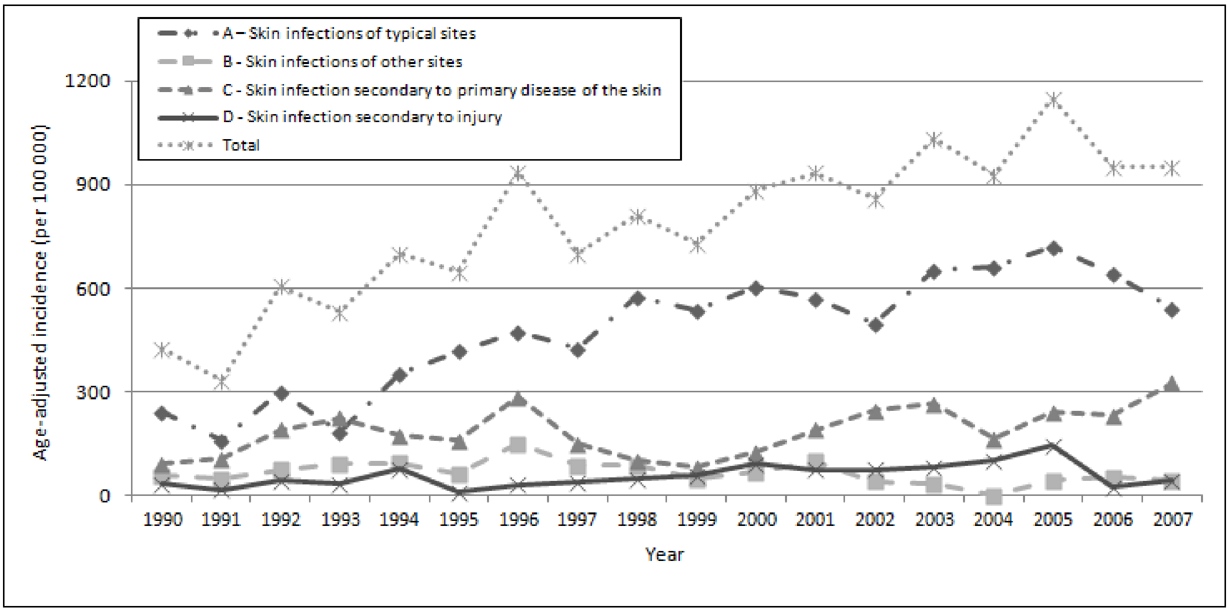

Figure 2. The incidence of serious skin infections in 0–14-year-old children in NZ by category and year, 1990–2007

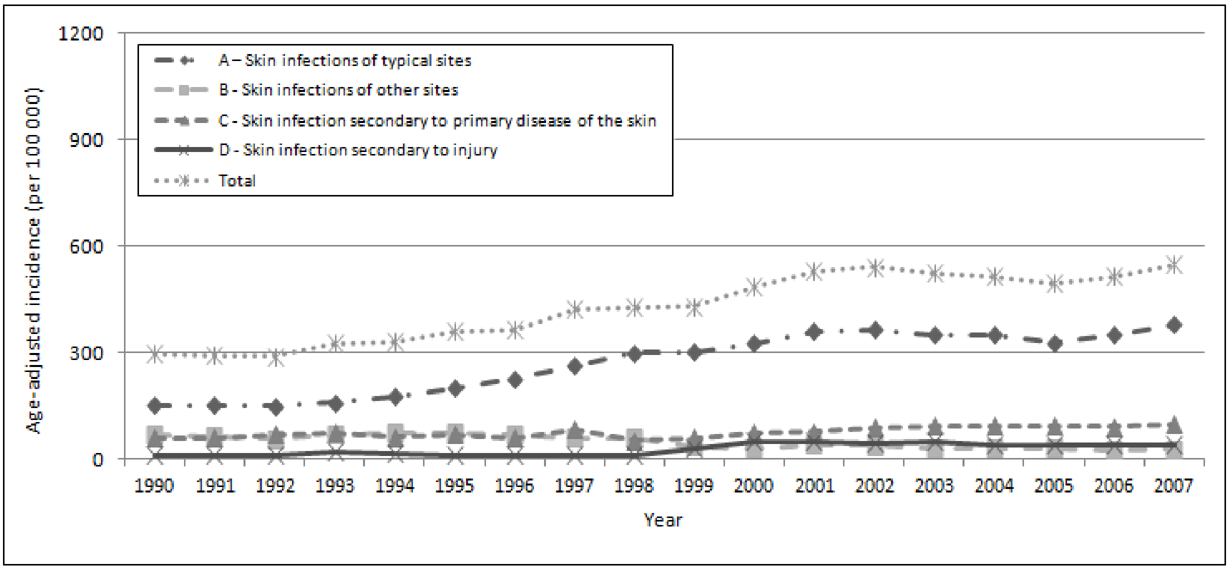

Table 2 shows the seasonal variation in the incidence of serious skin infections. In NZ, the crude incidence of infections was significantly higher during summer and autumn compared to winter (RR 1.12 for both). This trend was less distinct in Tairawhiti, with no significant difference in the seasonal incidence of infections. There was, however, no statistically significant difference in this trend between Tairawhiti and NZ.

Table 2. The crude incidence of serious skin infections in 0-14 year old children by season, gender, age group, ethnicity and deprivation level for the Tairawhiti region and NZ, 1990–2007

Variable	Category	Tairawhiti region			New Zealand			Difference in RRs#
		Freq	Rate	RR (95% CI)	Freq	Rate	RR (95% CI)	*p*
Season†	Autumn	450	823.0	1.01(0.95-1.08)	17176	457.9	1.12(1.11-1.14)	0.42
	Winter	445	813.9	1.00*	15290	407.6	1.00*	
	Spring	391	715.1	0.88(0.82-0.94)	15000	399.9	0.98(0.97-0.99)	0.42
	Summer	425	777.3	0.96(0.90-1.02)	17102	455.9	1.12(1.11-1.13)	0.24
Gender	Male	935	834.1	1.15(1.09-1.20)	37349	485.7	1.31(1.30-1.32)	0.25
	Female	776	727.8	1.00*	27218	372.1	1.00*	
	Unknown				1			
Age	0-4 yr	988	1364.0	2.99(2.81-3.17)	36376	733.3	2.99(2.96-3.02)	1.00
	5-9 yr	394	530.9	1.16(1.08-1.25)	15873	316.0	1.29(1.27-1.30)	0.43
	10-14 yr	329	456.6	1.00*	12319	245.4	1.00*	
Ethnicity	Māori	1312	1068.0	2.56(2.43-2.71)	23736	694.8	1.97(1.96-1.99)	0.05
	Non-Māori	399	416.4	1.00*	40832	352.4	1.00*	
NZDep‡	1-2	18	262.2	1.00*	5313	207.3	1.00*	
	3-4	72	364.9	1.39(1.08-1.79)	7190	270.6	1.31(1.28-1.33)	0.90
	5-6	72	227.3	0.87(0.67-1.11)	9462	336.3	1.62(1.60-1.65)	0.03
	7-8	130	428.5	1.63(1.29-2.08)	14045	451.5	2.18(2.14-2.21)	0.17
	9-10	1414	1200.9	4.58(3.66-5.74)	28102	788.2	3.80(3.75-3.86)	0.21
	Missing§	5						
Total		**1711**			**64568**			

Freq: frequency of cases for the entire period; Rate: average annual incidence per 100 000; RR: rate ratio.

† Where Autumn is considered March, April, May; Winter is June, July, August; Spring is September, October, November; and Summer as December, January and February.

‡ The New Zealand Deprivation Index (NZDep) is a measure of socioeconomic deprivation based on nine variables extracted from census data.[14] NZDep 1 indicates least deprivation and 10 indicates highest deprivation.

§Missing refers to cases with domicile codes that could not be linked to CAUs.

*Arbitrary reference category.

Compares the RR of each variable between the Tairawhiti region and NZ, with p<0.05 indicating a statistically significant difference between settings.

Incidence by age, gender, ethnicity, and deprivation level, 1990–2007—Table 2 details the crude incidence of serious skin infections in both the Tairawhiti region and NZ by a range of patient characteristics.

Boys had a significantly greater risk of suffering a serious skin infection than girls in both settings, with an incidence of 834.1/100 000 in male children compared to 727.8/100 000 in female children in the Tairawhiti region (RR 1.15) and 485.7/100 000 compared to 372.1/100 000 in NZ (RR 1.31). There was no difference in this trend between settings (p 0.25).

The incidence of skin infections decreased with increasing age. Preschool-aged were at the greatest risk with three times the rate of infections compared with 10-14 year old children in both settings (RR 2.99 in Tairawhiti and NZ). While the Tairawhiti region had a greater incidence of serious skin infections in all age groups compared with the NZ population, there was no significant difference in the age-distribution between settings.

In the Tairawhiti region, the incidence of serious skin infections in Māori children was 1068.0/100 000, over double the non-Māori rate of 416.4/100 000 (RR 2.56). In NZ the incidence of infections was not only lower in both groups (Māori 694.8/100 000, non-Māori 352.4/100 000), but the disparity between them was significantly less (RR 1.97, p 0.05).

In both Tairawhiti and NZ the incidence of serious skin infections was lowest in areas of least deprivation and increased with rising deprivation levels. The ratio of deprivation appeared greater in the Tairawhiti region, where the incidence of serious skin infections in the most deprived children was over four times higher than the incidence in least deprived children (RR 4.58 in Tairawhiti compared with RR 3.80 in NZ), however this difference did not reach statistical significance.

Indirect standardisation—The results of the indirect standardisation analysis are presented in Table 3. From 1990 to 1999 there were 793 children living in the Tairawhiti region discharged from hospital with a diagnosis of a serious skin infection, double the crude expected number of 398.2 discharges (O:E 1.99, 95%CI 1.86–2.14). Between 2000 and 2007 there were 913 observed discharges, also double the crude expected number of 453.8 discharges (O:E 2.01, 95%CI 1.88–2.15).

Table 3. The ratio of observed to expected childhood serious skin infection discharges in the Tairawhiti region after indirectly standardising age, deprivation and ethnicity to the NZ population, 1990–1999 and 2000–2007

Period	Variable(s) standardised	Expected number of discharges	Observed number of discharges	Ratio observed to expected discharges (O:E)	95% CI
1990–1999	None (crude)	398.2	793	1.99	1.86–2.14
	Age	399.8	793	1.98	1.85–2.13
	Ethnicity	481.7	793	1.65	1.53–1.76
	Deprivation	545.6	793	1.45	1.35–1.56
	Age, ethnicity	478.2	793	1.66	1.54–1.78
	Age, deprivation	540.7	793	1.47	1.37–1.57
	Ethnicity, deprivation	567.4	793	1.40	1.30–1.50
	Age, ethnicity, deprivation	559.9	793	1.42	1.32–1.52
2000–2007	None (crude)	453.8	913	2.01	1.88–2.15
	Age	451.4	913	2.02	1.89–2.16
	Ethnicity	571.8	913	1.60	1.49–1.70
	Deprivation	676.9	913	1.35	1.26–1.44
	Age, ethnicity	559.6	913	1.63	1.53–1.74
	Age, deprivation	665.0	913	1.37	1.29–1.46
	Ethnicity, deprivation	730.2	913	1.25	1.17–1.33
	Age, ethnicity, deprivation	715.8	913	1.28	1.19–1.36

Age-standardisation produced little change in the expected number of discharges in either 1990–1999 (O:E 1.98, 95%CI 1.85–2.13) or 2000–2007 (O:E 2.02, 95%CI 1.89–2.16). Adjusting for the ethnic composition of the region produced more of an effect, reducing the number of observed discharges to 65% more than expected in 1990–1999 (O:E 1.65, 95%1.53–1.76) and 60% more in 2000–2007 (O:E 1.60, 95%CI 1.49–1.70). Deprivation-standardisation reduced the difference even further, although there were still 45% more observed than expected discharges in 1990–1999 (O:E 1.45, 95%CI 1.35–1.56) and 35% more in 2000–2007 (O:E 1.35, 95%CI 1.26–1.44).

After standardising the Tairawhiti population composition to that of the NZ population by age, ethnicity and deprivation in combination, the observed number of discharges was still 42% higher than the expected number of 559.9 cases in 1990–1999 (O:E 1.42, 95%CI 1.32–1.52) and nearly a third higher than the expected 715.8 cases in 2000–2007 (O:E 1.28, 95%CI 1.19–1.36).

Discussion

This is the first published study to describe the epidemiology of serious skin infections in children in the Tairawhiti region, an area of NZ with the highest national incidence of these infections. Findings showed that while serious skin infections are an important and increasing problem for all NZ children, the incidence in Tairawhiti is almost double that nationally, with no reduction in this difference over time.

During the last 18 years the observed infection rates been significantly greater than that expected, despite taking into account the higher risk population composition of this region. In addition, already large ethnic disparities in national infection rates are considerably wider in the Tairawhiti region.

The disparity between infection rates in Māori and non-Māori children in Tairawhiti was significantly greater than that observed nationally. In a region that is already suffering the highest incidence of infections nationally, and is home to one of the largest Māori populations in NZ, this inequality is of particular concern.

Māori generally experience higher rates of infectious diseases than non-Māori.[16] The reasons for this disparity are complex and multifactorial; they are likely to include household overcrowding, barriers to accessing primary healthcare and a range of socioeconomic factors.[16–20]

Pacific Peoples form an important and unique proportion of the NZ population that are known to suffer particularly high rates of skin infections.[9] Due to the small number of Pacific Peoples in the Tairawhiti region a separate analysis of this ethnic group (and likewise other ethnic groups) was not undertaken. It is worth noting that by not analysing Pacific Peoples separately, the disparity between infection rates in Māori and non-Māori children is likely to be underestimated.

Socioeconomic deprivation was an important risk factor for infection, with children from highly deprived neighbourhoods in the Tairawhiti region more than four times as likely to suffer a serious skin infection as their least deprived counterparts. Similar disparities were observed in the national population. This association has been described previously and is likely to be linked to ethnic inequalities as discussed below. Other mediating factors are thought to include hygiene, nutrition, household crowding, and the ability to access timely medical care.[5-7,21-24]

In both Tairawhiti and NZ populations, boys and preschool-aged children were found to be at a greater risk of serious skin infections than girls and children over the age of 5 years. This finding could reflect an increased frequency of minor skin trauma in these groups or delays in seeking medical care. While it is unlikely that gender affects hospitalisation practices, it is possible that age trend is in part due to a lower threshold for hospital admission in younger children.

Interestingly, the usual seasonal trends in skin infection rates were not observed in the Tairawhiti region. Previous analyses have found the greatest incidence during the late Summer and early Autumn months,[2,5,6,8,10,22-26] thought to be due to warmer air temperatures leading to more frequent insect bites, deficiencies in hygienic precautions, and the wearing of loose clothing exposing skin to skin contact and minor trauma.[3,27,28] It is possible that the year-round warmer temperatures in the Tairawhiti region results in less seasonal fluctuation.

Previous work has suggested Tairawhiti DHB's elevated incidence of childhood serious skin infections could be solely due to the 'high-risk' population structure.[6] We investigated this hypothesis by using indirect standardisation to control for the age, ethnicity and deprivation composition of the region.

Adjusting for these population variables did reduce the difference between the number of skin infections observed and expected, with deprivation and ethnicity standardisation producing the largest reductions. However, even after taking all three factors into account, the observed rate of infections was still significantly greater than the expected rate, by 42% in 1990–1999 and 28% in 2000-2007. This persisting difference suggests that other unaccounted for or unknown factors are contributing to the high disease burden in the Tairawhiti region.

A proportion of the local population, particularly in rural settings, lacks reticulated water and relies on rainwater tanks leading to lack of sufficient water for washing in the dry summer months. Local rivers are often used for bathing in the summer. The effect of water supply and other local environmental factors on the development of skin infections warrants further investigation. Similarly it is important to investigate access to health services and the potential role that the local normalisation and acceptance of skin infections may play in delays in seeking medical care.

It is also possible that the risk of skin infection has a non-linear relationship with the size of the vulnerable population in a region. This outcome could be observed if there are high rates of carriage of the organisms causing skin infections in these same vulnerable population groups. Finally, it is possible that some of the difference between observed and expected infection incidence could be due to misclassification of risk categories, such as deprivation and ethnicity. The influence that this last factor may have had on the results is unknown.

Indirect standardisation is limited in that it cannot be used to compare a population over time, hence we could not analyse the changes in the ratios between 1990–1999 and 2000-2007. Likewise it cannot be used to compare different populations, such as other DHBs. Direct standardisation would enable these comparisons, but due to small numbers in some age-ethnic-deprivation groups, this analysis was not viable.

Hospitalisation data have strengths and weaknesses as a basis for the surveillance of serious skin infections. The main limitation of these data is that, by definition, they only represent the 'tip of the iceberg' and cannot on their own provide a measure of the total incidence of skin infections in the community. This is a limitation that is common to other areas of infectious disease epidemiology where the clinical condition is on a continuous disease spectrum and any case definition will be somewhat arbitrary.[29]

The strengths of this data source are that it is accessible and likely to be relatively sensitive as, by definition, serious skin infections are those skin infections which require overnight hospitalisation for treatment.[13] On this basis we used the term 'incidence' to describe hospitalisation rates. It is possible that the sensitivity of such surveillance has changed over time, such as the increased recording of day patients as admissions, however our use of a high threshold for inclusion (notably the requirement for a minimal one night admission) should minimise this effect.

Modifications to the ICD coding system may have contributed to changes in surveillance over time; despite using standardised mapping tables the frequency of some diagnoses varied markedly between the two periods studied (see Appendix). However, as there was a steady increase in the total infection incidence over the years when the major ICD revision occurred (from ICD-9 to ICD-10), the variation is likely to reflect inter-code and inter-category drift and gives further justification to our use of a more inclusive case definition than that used previously.

It is likely that the threshold for hospitalisation varies regionally; geographical and social considerations may favour overnight admission in Tairawhiti, while larger paediatric centres may be more equipped to admit children for day stay operative procedures rather than overnight. While these differences need to be considered, it is unlikely they account for more than a small proportion of the difference in incidence rates.

Finally, while age-adjusted rates were calculated for the overall incidence of infections, age stratified rates could not be obtained for all variables so crude rates are presented in some cases. However, both national and regional populations do not significantly differ with the WHO standard population, which indicates that age-standardisation for individual variables is unlikely to make a significant difference to our findings.

This study highlights a need for action to prevent serious skin infections in the children of both the Tairawhiti region and throughout NZ. Further work is required to better understand the cause of these infections and the measures which will most effectively reduce their incidence. Investigating the aetiological processes contributing to the development of serious skin infections in the Tairawhiti region could take the form of a retrospective case note review (see article entitled *Serious skin infections in children: a review of admissions to Gisborne Hospital (2006–2007)* in this issue of *The New Zealand Medical Journal)*, a prospective case series, or a case-control study, and would assist in determining areas to most effectively direct local interventions.

The epidemiology of skin infections in primary care and the wider population is largely unknown; future study in this area could improve our understanding of whether inequalities in serious skin infection rates are a direct reflection of similar trends in the community (see article entitled *Skin infections in children in a New Zealand primary care setting: exploring beneath the tip of the iceberg* in this issue of *The New Zealand Medical Journal*).

In combination with the findings of this study, ongoing work could aid in reducing serious skin infection morbidity and narrowing health inequalities for children in both the Tairawhiti region and wider NZ.

Competing interests: None declared.

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Appendix 1. The incidence of serious skin infections in 0–14-year-old children in Tairawhiti and NZ, 1990–2007, disaggregated by ICD code, coding category and level of diagnosis

				Tairawhiti		New Zealand	
CATEGORY A ICD codes (skin infection sub-chapter of ICD-10)	**ICD-10**	**ICD-9**	**Level of diagnosis**	**Rate 1990-1999†**	**Rate 2000-2007†**	**Rate 1990-1999†**	**Rate 2000-2007†**
Impetigo	L01.0-L01.1	684	Principal	17.8	17.9	7.9	10.1
			All level	57.4	57.9	18.2	23.5
Cutaneous abscess, furuncle and carbuncle	L02.0-L02.9	6800-6809	Principal	18.6	185.3	9.4	107.4
			All level	21.8	208.5	11.1	118.3
Cellulitis	L03.01-L03.9	68100-68102, 68110, 68111, 6819-6829	Principal	225.5	209.5	126.5	122.6
			All level	250.5	268.5	146.7	160.3
Acute lymphadenitis	L0.40-L04.9	683	Principal	5.7	20.0	6.8	15.0
			All level	5.7	24.2	7.8	17.0
Pilonidal cyst with abscess	L05.0	6850	Principal	0.8	3.2	0.5	1.6
			All level	0.8	3.2	0.6	1.6
Pyoderma	L08.0	6860	Principal	0.8	0.0	0.4	0.7
			All level	0.8	6.3	1.2	6.6
Other infections of skin and subcutaneous tissue	L08.1,L08.8, L08.9	390, 6868-6869, 9101-9179, 9191-9199	Principal	15.4	17.9	17.5	7.7
			All level	31.3	43.2	24.1	23.7
Total			**Principal**	**284.5**	**453.8**	**166.3**	**264.9**
			All level	**368.5**	**610.7**	**209.7**	**351.0**
CATEGORY B ICD codes (serious skin infections of atypical anatomical sites)							
Erysipelas	A46	035	Principal	0.0	1.1	0.5	0.3
			All level	0.8	1.1	0.6	0.4
Hordeolum/cellulitis/abscess eyelid	H00.0	37311-37313	Principal	13.7	10.5	3.8	6.5
			All level	16.2	10.5	4.6	8.1
Abscess/cellulitis external ear and infective otitis externa	H60.0-H60.3, H62.0, H62.4	38010, 38011, 38013, 38014	Principal	9.7	9.5	7.4	5.5
			All level	21.0	15.8	12.0	7.8
Abscess/cellulitis nose	J34.0	4781	Principal	5.7	2.1	8.5	1.6
			All level	11.3	2.1	25.5	1.9
Anal abscess/cellulitis (excludes rectal, ischiorectal or intersphincteric regions)	K61.0	566	Principal	17.8	8.4	8.2	7.2
			All level	17.8	8.4	8.6	7.8
Acute inflammation/cellulitis/abscess of orbit	H05.0	37600-37601	Principal	8.9	0.0	7.2	2.1
			All level	10.5	0.0	9.0	2.3
Other inflammatory disorders of penis, scrotum and unspecified male genital organ (excludes deeper	N48.2,N49.2, N49.9	6072, 6084	Principal	1.6	4.2	1.8	1.4
			All level	2.4	5.3	2.4	2.2

tissues)							
Abscess/cellulitis of vulva	N76.4	6164	Principal	0.8	3.2	1.6	2.5
			All level	0.8	4.2	1.6	2.7
Total			**Principal**	**58.2**	**39.0**	**38.9**	**27.2**
			All level	**80.8**	**47.4**	**64.3**	**33.1**
CATEGORY C ICD codes (serious skin infections secondary to primary skin disease)							
Varicella with other complications	B01.8	0527-0528	Principal	9.7	11.6	2.9	3.9
			All level	12.9	12.6	3.6	4.6
Scabies	B86	1330	Principal	12.9	3.2	3.3	1.3
			All level	28.3	16.8	15.6	7.3
Dermatitis unspecified and other specified (eczema) and infective eczema‡	L30.8,L30.9, L30.3 0	6908, 6929, 7028	Principal	42.8	71.6	11.0	22.5
			All level	115.6	193.7	46.6	78.0
Total			**Principal**	**65.5**	**86.3**	**17.3**	**27.8**
			All level	**156.8**	**223.2**	**65.9**	**89.9**
CATEGORY D ICD codes (serious skin infections secondary to external trauma)							
Insect/spider bites	S10.13,S10.83,S10.93,S20.13,S20.33,S20.43,S20.83,S30.83,30.93,S40.83,S50.83,S60.83,S70.83,S80.83,S90.83,T00.9,T09.03,T11.08,T13.03,T14.03,T14.03,T63.3,T63.4	9104, 9114, 9124, 9134, 9144, 9154, 9164, 9174, 9192, 9194, 9198, 9248, 9895	Principal	15.4	12.6	5.8	4.2
			All level	27.5	15.8	7.9	6.6
Post-traumatic wound infection not elsewhere classified	T79.3	9583	Principal	3.2	3.2	1.9	1.6
			All level	8.1	10.5	5.4	6.7
Open wound infection with foreign body (+-infection) and open wound with infection	T89.01,T89.02	8799	Principal	1.6	0.0	0.1	0.3
			All level	3.2	53.7	2.2	31.9
Total			**Principal**	**20.2**	**15.8**	**7.8**	**6.1**
			All level	**38.8**	**80.0**	**15.6**	**45.2**

†Average annual incidence per 100 000 in 1990-1999 and 2000-2007 by discharge diagnosis code with Category A prioritisation (Categories B-D exclude admissions already included by a code in Category A, then by a code in Category B, then by a code in Category C).

‡The medical definition of infective eczema (a primarily inflammatory condition) is not in keeping with the clinical description of a serious skin infection, however due to similarities in terminology, this code is incorrectly used for eczema with a superficial bacterial infection.