Childhood admissions to hospital for serious skin infections in the Toi Te Ora Public Health area

(Bay of Plenty District Health Board and Lakes District Health Board)

2018

Summary

One of the goals of Toi Te Ora Public Health (Toi Te Ora) stated in the strategic plan for 2013-2025 was:

"To reduce childhood admission to hospital from acute rheumatic fever, respiratory infections and skin infections, each by 2/3 in five years".

One component of this goal is childhood skin infection and that is the focus of this report. The baseline year for the goal was 2013.

This report presents an analysis of skin infection hospitalisation data for children in the Toi Te Ora area children based on an extract from the National Minimum Data Set (NMDS) for residents of Bay of Plenty and Lakes District Health Boards, children aged 0-14 years. The analysis uses the O'Sullivan & Baker (2010) case definition for serious skin infection. This case definition includes diagnostic codes for all conditions which meet the clinical description of a serious skin infection.

The aim of this analysis is to get an updated view of child health statistics for these conditions and to assist with determining what Toi Te Ora should focus on to reduce child hospitalisations for skin infections.

Key findings:

- The total number of serious skin infection cases has been reducing from 489 in 2013 to 378 in 2016.
- The rate of serious skin infection for Toi Te Ora has reduced to the lowest level in 2016 since the beginning of the time series in 2001. However the rate is still significantly higher than the average rate for New Zealand.
- The rate of serious skin infection has reduced to a greater extent in Bay of Plenty District Health Board (DHB) compared to Lakes DHB.
- The highest rates occur in very young children, 0-2 year old children have rates above 100 per 10,000 and in 4-14 year olds the rate is stable at approximately 50 per 10,000. For every age the rate for Toi Te Ora is greater than the average New Zealand rate for the same age group.
- Māori children experience a high rate of serious skin infection. Ethnic inequalities still persist despite decreasing rates of serious skin infection in Māori and Non-Māori, Asian and Pacific. The magnitude of the inequality has fluctuated from 2001-2016 and the inequality has not been reduced for a sustained period of time
- The incidence of serious skin infection is strongly correlated with socioeconomic deprivation in both Māori children and Non-Māori children.

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1 Introduction

Skin infection is a preventable illness in childhood. If skin infections are left untreated they can have serious consequences including prolonged hospital stays.

This report updates the analysis of serious skin infection previously undertaken by Toi Te Ora Public Health (Scarfe, 2014; Toi Te Ora, 2016). Serious skin infections are infections which require treatment in hospital. In terms of the burden of disease caused by skin infections, serious skin infection represents the tip of the iceberg. Research undertaken in Gisborne New Zealand estimated that for each case of serious skin infection there are a further 14 cases of skin infection treated in general practice (O'Sullivan & Baker, 2012).

Toi Te Ora Public Health has committed to three ambitious public health goals. One of those goals is to reduce the rate of hospital admissions for childhood infections by two thirds. Childhood infections include respiratory infection, skin infection and rheumatic fever.

Appendix 1 of this report provides of summary of New Zealand skin infection literature published between 2015 and February 2018. The volume of New Zealand research produced in this period shows that skin infection is still a significant cause of illness in children and an important child health issue.

2 Methods

This section provides the details of the case definition, sources of data and the analysis techniques used.

2.1 Case definition

The O'Sullivan & Baker (2010) case definition of serious skin infection was utilised in this analysis (Table 1). This case definition and variations of it has now been used extensively in the New Zealand literature on skin infection.

Table 1: Epidemiological case definition for serious skin infection in children (O'Sullivan & Baker, 2010 p181)

A child aged 0–14 years, admitted to hospital with a principal or additional diagnosis of serious skin infection, with a diagnosis code either within the ICD skin infection subchapter or within the categories of skin infection of an atypical site or skin infection following primary skin disease or external trauma.

The case definition is further divided into four categories based on the type, site and cause of the infection. The categories are defined by ICD-10 codes in (Table 2).

Table 2: Coding categories of serious skin infection

Category A ICD-10 codes (serious skin infection of typical sites)	
L01.0, L01.1	impetigo
L02.0–L02.9	cutaneous abscess, furuncle and carbuncle
L03.01–L03.9	cellulitis
L0.40–L04.9	acute lymphadenitis
L05.0	pilonidal cyst with abscess
L08.0	pyoderma
L08.1, L08.8, L08.9	other infections of skin and subcutaneous tissue
Category B ICD-10 codes (serious skin infections of atypical anatomical sites)	
A46	erysipelas
H00.0	hordeolum/cellulitis/abscess eyelid
H60.0–H60.3, H62.0, H62.4	abscess/cellulitis external ear and infective otitis externa
J34.0	abscess/cellulitis nose
K61.0	anal abscess/cellulitis (excludes rectal, ischiorectal or intersphincteric regions)
H05.0	acute inflammation/cellulitis/abscess of orbit
N48.2, N492, N49.9	other inflammatory disorders of penis, scrotum and unspecified male genital organ (excludes deeper tissues)
N76.4	abscess/cellulitis of vulva
Category C ICD-10 codes (serious skin infections secondary to primary skin disease)	
B01.8	varicella with other complications
B86	scabies
L30.8, L30.9, L30.3 0	dermatitis unspecified and other specified (eczema) and infective eczema
Category D ICD-10 codes (serious skin infections secondary to external trauma)	
S10.13, S10.83, S10.93, S20.13, S20.33, S20.43, S20.83, S30.83, S30.93, 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	insect/spider bites
T79.3	post-traumatic wound infection not elsewhere classified
T89.01, T89.02	open wound infection with foreign body ± infection and open wound with infection

To ensure the discharge record represents a true case four additional criteria were specified to screen the discharge records (Table 3).

Table 3: Criteria for excluding cases in the discharge records (O'Sullivan, Baker, & Zhang, 2011)

- Transfers were excluded to avoid double counting of incident cases
- Readmissions within 30 days with the same principal diagnosis were excluded as incident cases are being counted. A readmission within 30 days is likely to be a continuation of the same event
- Day cases were excluded due to inconsistencies in data recording over time
- Non-residents were removed to ensure a better match with population denominators.

2.2 Geographic areas

Multiple geographic areas are used in the analysis of serious skin infection. Table 4 describes the geographic areas used in this report.

Table 4: Description of geographic areas used in the analysis of the serious skin infection data

Geographic Area	Description
Census Area Unit (CAU)	Small geographic area created by Statistics New Zealand for the census. In urban areas CAUs are similar to areas recognised as suburbs and are of similar population size. In rural areas CAUs can represent a very large sparsely populated area.
Local Authorities	Geographic boundaries of district councils and city councils. Toi Te Ora contains one city council and six district councils.
Sub-regions	A geographic area used by Toi Te Ora public health which groups local authorities into sub-regions with similar demographics. Toi Te Ora is divided into four sub regions: - **Western Bay** – Tauranga City and Western Bay of Plenty District Council - **Eastern Bay** – Whakatane District Council, Kawerau District Council and Opotiki District Council - **Rotorua** – Rotorua District Council - **Taupo** – Taupo District Council
District Health Board (DHB)	A geographic area defined for the purpose of the provision of health services
Toi Te Ora	The Public Health Unit area where Toi Te Ora Public Health provides public health services. The area comprises the geographic area defined by the boundaries of Lakes DHB and Bay of Plenty DHB.

2.3 Data sources

The National Minimum Data Set (NMDS) of hospital discharges was obtained for the period of the analysis. The discharge records in the NMDS include the admission date and discharge date, each individual in the dataset is assigned a unique anonymised identifier to enable repeat discharges for the same individual to be identified.

2013 census data, DHB population projections (Statistics New Zealand, 2015; Statistics New Zealand, 2014), and Statistics New Zealand population estimates and projections were used for the denominator in the calculation of rates. Table 5 displays a summary of the denominators used in different situations.

The New Zealand Index of Deprivation 2013 (NZDep2013) was used for analysis of skin infection by socioeconomic status.

Table 5: Summary of dominator used

Level	Denominator
New Zealand and DHB rates by age groups and ethnicity	DHB population projections
Sub regions and local authorities	Statistics New Zealand population estimates and projections
Single year age groups	2013 census
Deprivation	2013 census

2.4 Data analysis

2.4.1 Applying the case definition

The analysis was carried out using Microsoft Excel 2010 and the NMDS for 2006-2016 was obtained from the Ministry of Health. For each record the dataset included the first 20 diagnoses, all of the records of people aged over 14 were removed from the dataset. Each diagnosis was categorised as an A, B, C or D type infection, as defined in the case definition, records which did not include a skin infection were removed from the dataset. Cases were identified as principal or secondary cases. Cases are considered principal cases if the skin infection diagnosis is the principal diagnosis. Category A type infections are given priority as was applied by O'Sullivan (2011). For example, if a record had a principal diagnosis of category C infection and a category A infection as a secondary diagnosis the record would be recorded as a secondary case of a category A type infection. In other cases of multiple skin infection diagnoses for a single record the case was assigned to the category of the first appearing diagnosis in the list of diagnoses.

In the results section of the reported rates are for all cases of serious skin infection (principal and secondary diagnosis skin infections).

After cases were identified four additional criteria were applied to the cases to ensure data quality and to ensure the population the counts come from matches the population of the denominator. The four criteria used are included in Table 3 (Page 6).

2.4.2 Calculation of incidence and confidence intervals

Age-specific rates of serious skin infection were calculated for gender, ethnicity, age groups and categories. The denominator used matched the area of analysis. For New Zealand, Toi Te Ora, and DHB rates the Ministry of Health population projections were used. Rates calculated at the sub region level used the Statistics New Zealand Population Projections. Rates calculated for deprivation quintiles and deciles used the usually resident population count of the 2013 census.

For some rates 95% confidence intervals are included. An unadjusted normally distributed confidence interval has been used. The normal distribution closely approximates a Poisson distribution for counts above 50. The following formulas were used to calculate the upper and lower limits:

$$Upper\ limit = \frac{10000}{d}\left(f + 1.96\sqrt{f}\right)$$

$$Lower\ Limit = \frac{10000}{d}(f - 1.96\sqrt{f})$$

$$where: d = population\ denominator, f = count\ of\ incident\ cases$$

Incidence ratios were calculated to make comparisons between gender, age groups, ethnicity and deprivation levels.

Confidence intervals can be used to test if the difference between two estimates is statistically significant. If the confidence intervals do not overlap, it will be assumed the difference between

estimates is statistically significant. If the confidence interval of one estimate includes the comparator estimate then the difference between estimates is not statistically significant.

If the confidence intervals of two rates overlap the difference in rates may or may not be statistically significant. To determine if the difference is statistically significant a rate ratio and its confidence intervals can be calculated. If the confidence interval of the rate ratio does not include one the difference is statically significant. Alternately a two-tailed z-test can be carried out. A p-value of less than 0.05 is considered to be statistically significant.

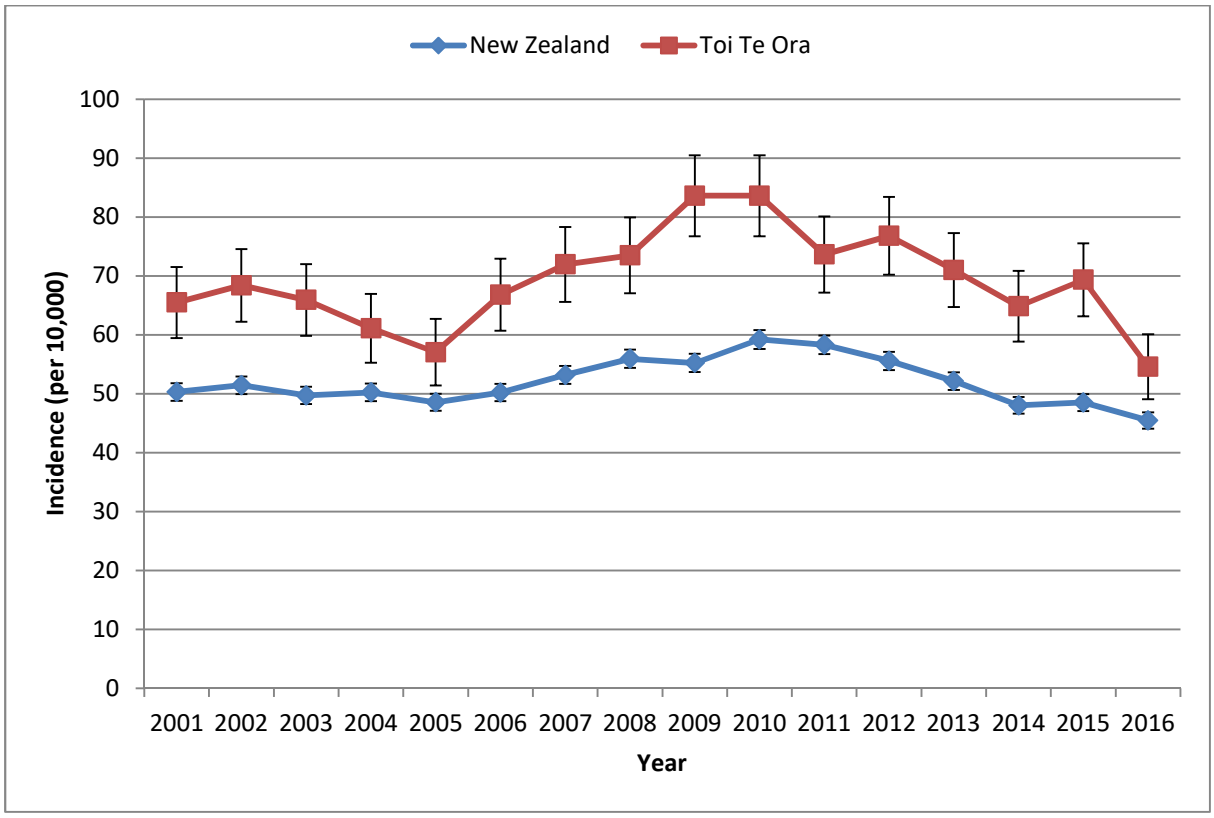
3 Results

The following presents the analysis results of serious skin infection. All counts presented are all serious skin infections unless stated as principal diagnosis only. Results described as a rate is the incidence of serious skin infection per 10,000 children.

3.1 Toi Te Ora compared with New Zealand

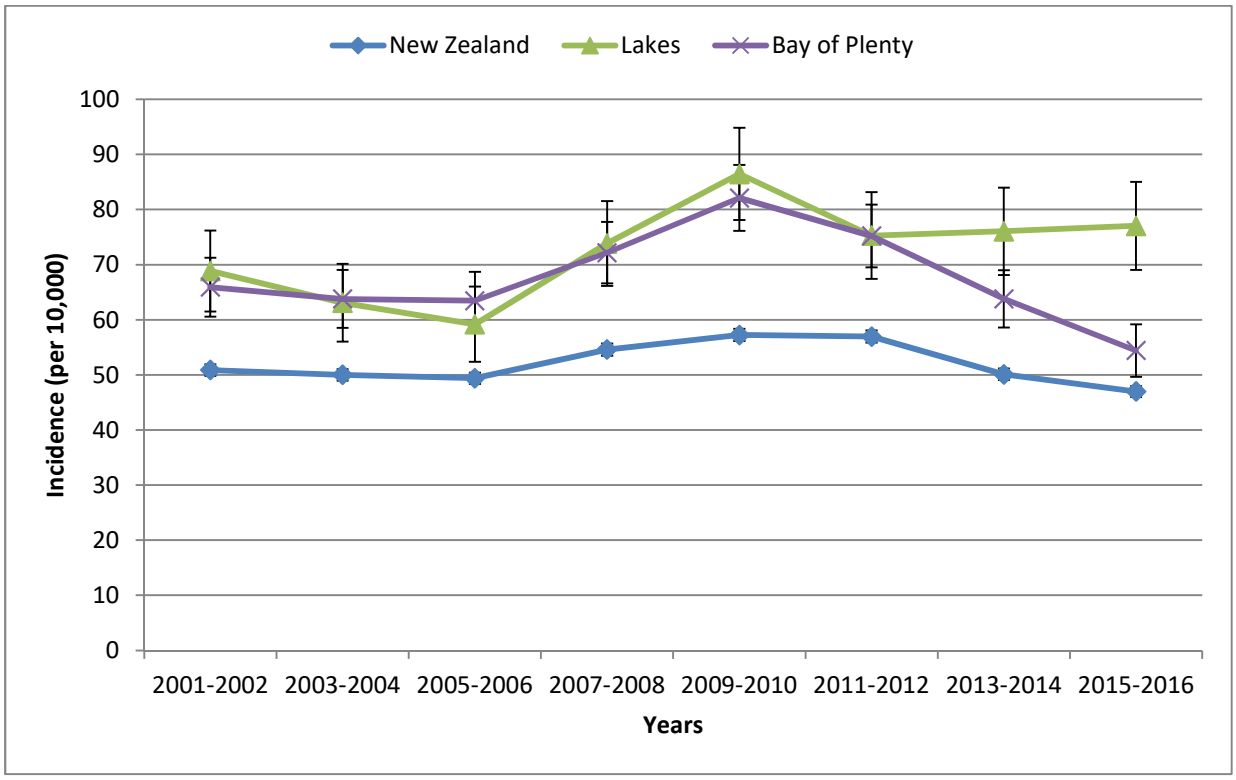
In New Zealand and Toi Te Ora the age-specific rate of serious skin infection for children aged 0-14 years increased from 2001 and peaked in 2010 (Figure 1). From 2011 onwards the rate decreased in New Zealand and Toi Te Ora. The lowest incidence of serious skin infection in both Toi Te Ora and New Zealand over the period 2001 to 2016 occurred in 2016. A table showing counts of all cases of serious skin infection by year for Toi Te Ora can be found in Appendix 2.

Figure 1: Incidence of serious skin infection in New Zealand and Toi Te Ora



When the Toi Te Ora rate is divided into separate rates for Bay of Plenty and Lakes it can be seen that from 2010 the rate of serious skin infection has been decreasing in Bay of Plenty while remaining constant in Lakes (Figure 2). This remains true when the data is stratified by ethnicity (Appendix 3). The incidence in Bay of Plenty and New Zealand has decreased since 2010. The decrease in the incidence in Bay of Plenty has been steeper than the decrease seen in New Zealand resulting in the Bay of Plenty incidence approaching the New Zealand incidence for the first time in the time series. The 2016 incidence for the Bay of Plenty is the lowest of the 15 year time period.

Figure 2: Average incidence of serious skin infection in New Zealand, Bay of Plenty, and Lakes



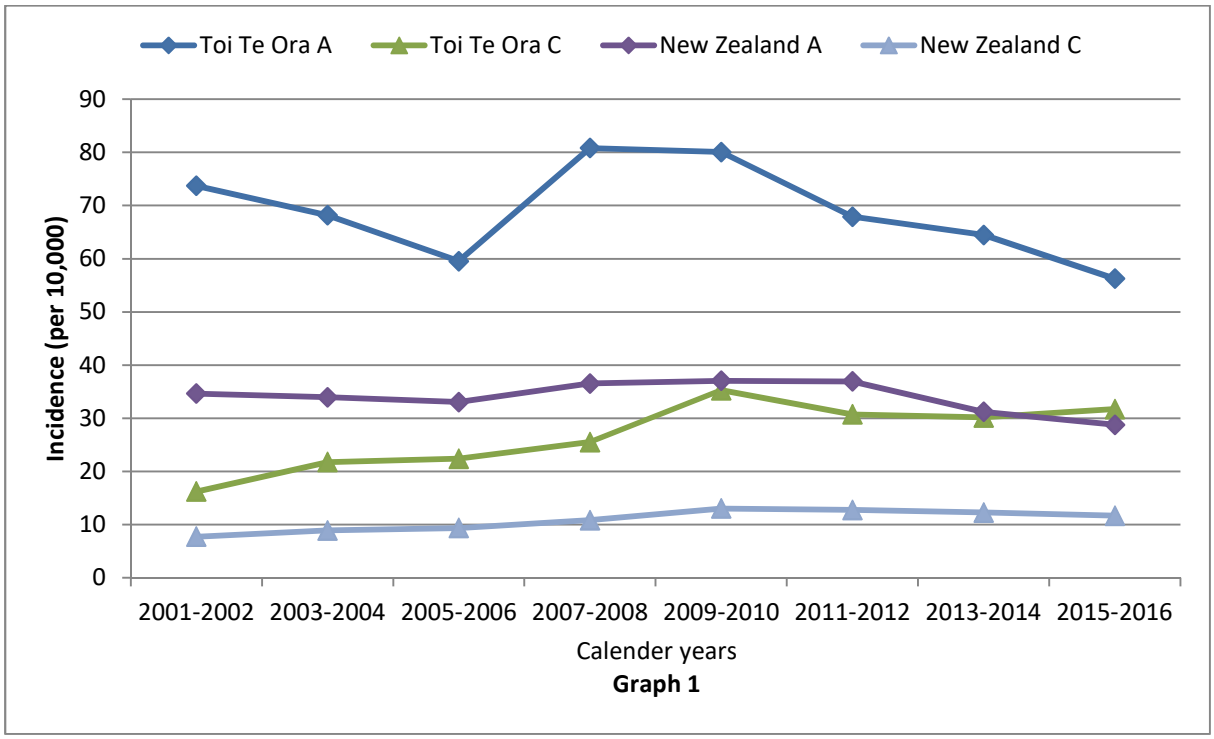
3.1.1 Categories

The case definition can be further divided into four categories (Table 2). Category A is skin infection of typical sites, category B skin infections are infections of atypical anatomical sites, category C skin infections are skin infections secondary to a primary disease of the skin and category D skin infection are skin infections secondary to external trauma. Essentially categories B, C and D capture infections which meet a clinical description of a skin infection but are classified outside of the ICD-10 skin subchapter.

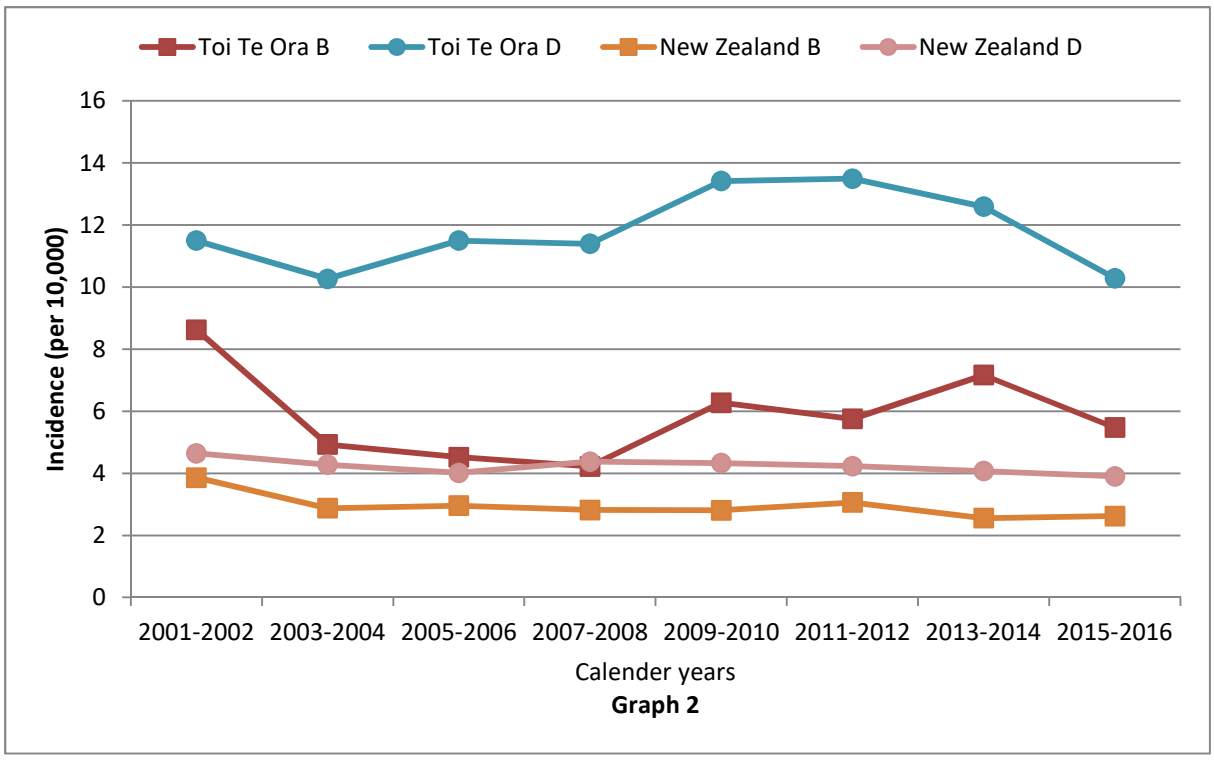
Within the Toi Te Ora area over the last eleven years the rate of category C serious skin infection has been increasing while the rate of category A infections has been decreasing (Figure 3). The incidence of category B and D infections has remained constant over the 11 year period.

Compared to the New Zealand, the Toi Te Ora area has a greater rate of category A, and D infections. The patterns seen in the Toi Te Ora data follows similar patterns to those seen in the New Zealand data.

Figure 3: Incidence of serious skin infection by category of infection. Graph 1 includes category A and C infections. Graph 2 includes category B and D infections



Graph 1



Graph 2

Specific conditions

The four categories are groupings of similar types of skin infection. Table 4 displays the number of incident cases for Toi Te Ora by the skin infection diagnosis for 2011-2013 and 2014-2016. In 2014-2016 compared to 2011-2013 large reductions in the number of cases were seen in cellulitis, cutaneous abscess, furuncle and carbuncle, varicella with other complications, and scabies. The reduction in scabies cases represents a reduction of 60%. There were no large increases for any of the conditions included in the case definition of serious skin infection.

Table 6: Number of serious skin infection cases by diagnosis

Skin Infection Diagnosis	2011 - 2013	2014 - 2016	Total 2011 - 2016
Category A - Skin infections of typical sites	**875**	**741**	**1616**
Impetigo	85	77	162
Cutaneous abscess, furuncle and carbuncle	258	213	471
Cellulitis	442	356	798
Acute lymphadenitis	35	40	75
Pilonidal cyst with abscess	7	4	11
Pyoderma	3	8	11
Other infections of skin and subcutaneous tissue	45	43	88
Category B - Skin infections of atypical sites	**81**	**65**	**146**
Erysipelas	2	1	3
Hordeolum/cellulitis/abscess eyelid	18	14	32
Abscess/cellulitis external ear and infective otitis externa	16	12	28
Abscess/cellulitis nose	5	3	8
Anal abscess/cellulitis (excludes rectal, ischiorectal or intersphincteric regions)	12	16	28
Acute inflammation/cellulitis/abscess of orbit	4	6	10
Other inflammatory disorders of penis, scrotum and unspecified male genital organ (excludes deeper tissues)	5	5	10
Abscess/cellulitis of vulva	19	8	27
Category C - Skin infections secondary to primary disease of the skin	**419**	**368**	**787**
Varicella with other complications	23	7	30
Scabies	85	34	119
Dermatitis unspecified and other specified (eczema) and infective eczema	311	327	638
Category D - Skin infections secondary to trauma	**133**	**129**	**262**
Insect/spider bites	24	27	51
Post-traumatic wound infection not elsewhere classified	23	18	41
Open wound infection with foreign body (+ infection) and open wound with infection	86	84	170

3.1.2 Gender

There are gender differences in the incidence of serious skin infection. The incidence rate ratio (Table 7) shows that the incidence for boys is 18% greater than the incidence for girls in 2015 and 2016. The difference in incidence between male and female is less in the Toi Te Ora area compared to the average for New Zealand.

Table 7: Incident rate ratio of serious skin infection for male compared to female in 20

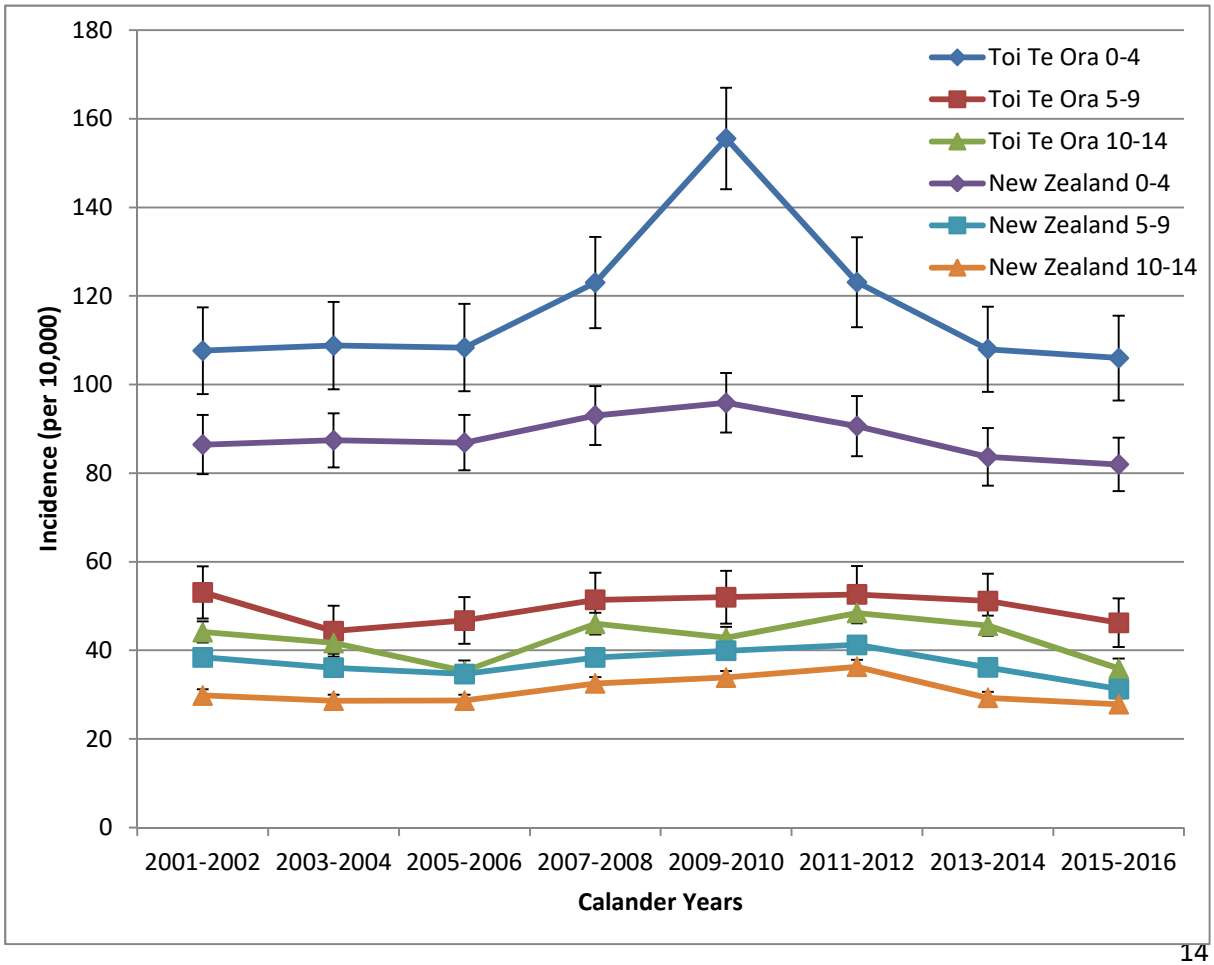
Gender	Toi Te Ora	New Zealand
Male	1.18 (1.07-1.28)	1.29 (1.26-1.33)
Female	1.0	1.0

3.1.3 Age

The 0-4 age group has the highest incidence of serious skin infection (

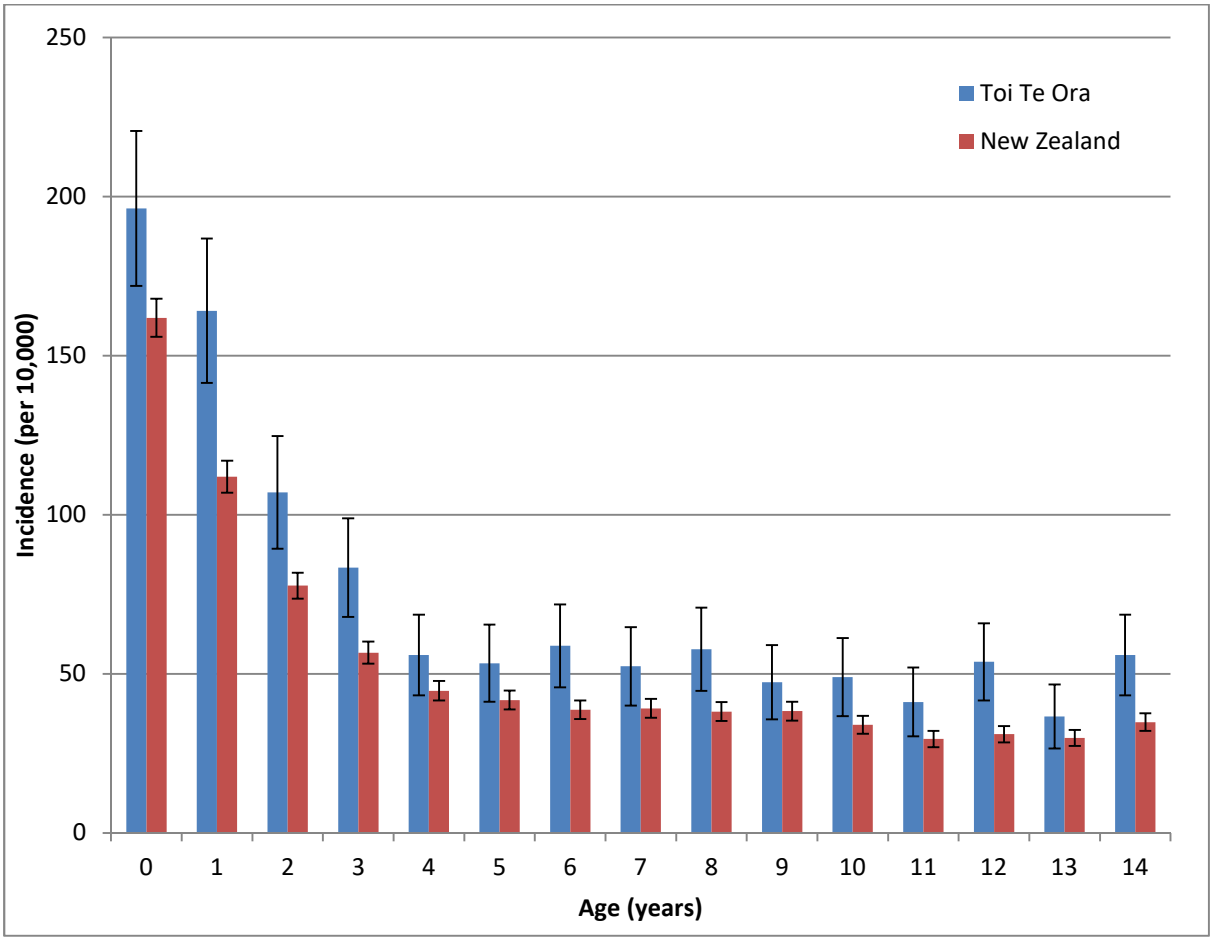
Figure **4**). The incidence is a lot lower for the remaining two age groups. The rate in Toi Te Ora for the 0-4 age group peaked in the 2009-2010 period and has fallen back to a level last seen in 2005-2007. It is not clear why the rate peaked in 0-4 year olds in 2009-2010 and then declined back to the original rate. For each age group the Incidence in Toi Te Ora is higher than the corresponding rate for New Zealand. The difference in rate is not due to a difference in the population demographics. When the rates are stratified by ethnicity the difference remains (Figure 8).

Figure 4: Incidence of serious skin infection by age group



The age groups can be further broken down into single year age groupings. The average incidence for 2012-2014 was calculated for each single year age group (Figure 5). The 2012-2013 period was selected because an accurate denominator for single year age groupings could be obtained from the 2013 Census. The single year age groups show the rate of serious skin infection is higher at all ages for Toi Te Ora compared with New Zealand. Within Toi Te Ora the rate levels off from the four year old age grouping onwards.

Figure 5: Average incidence of serious skin infection by age for 2012-2014

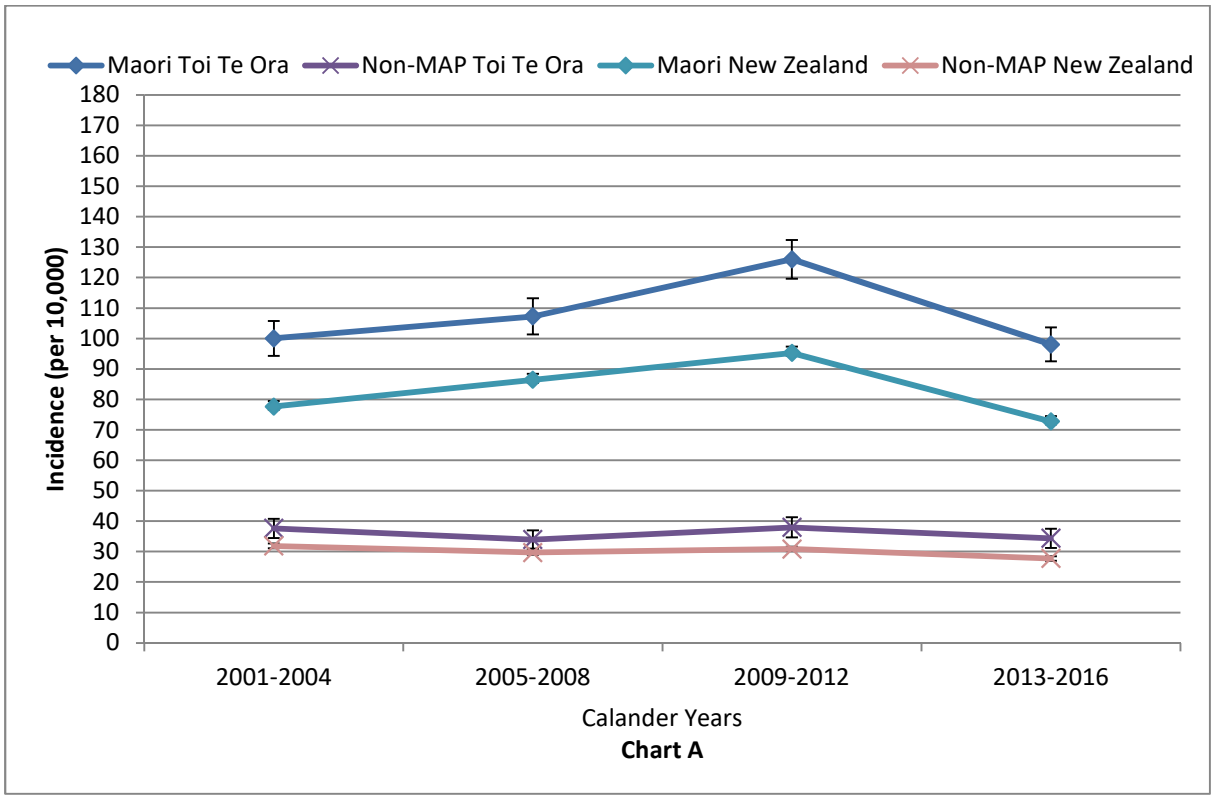


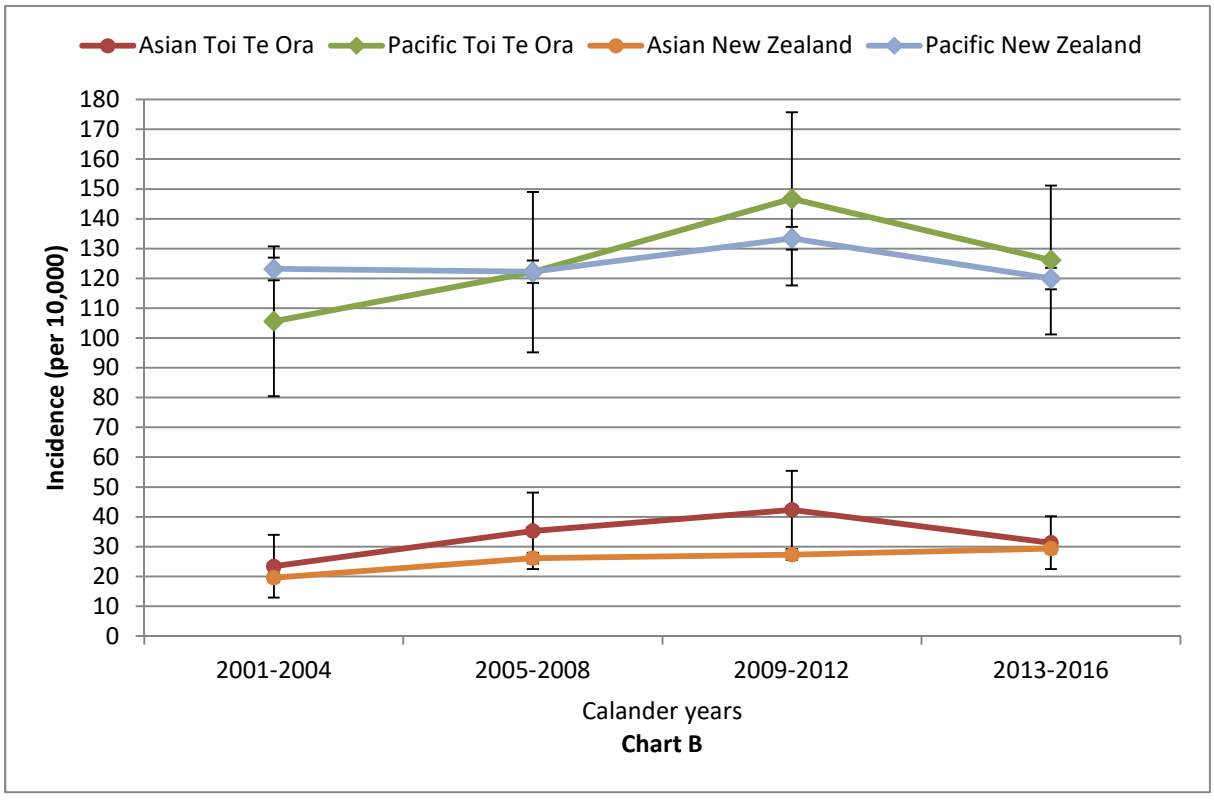
3.1.4 Ethnicity

The incidence of serious skin infection varies by ethnicity in Toi Te Ora and New Zealand (Figure 6). In Figure 6 the four year average incidence is used due to the small population size of the Asian and Pacific ethnicities in Toi Te Ora. During 2013-2016 the average incidence in Toi Te Ora for both Asian and Pacific ethnicities was not statistically significantly different to the New Zealand rates. This is not the case for Māori and Non-Māori, Asian or Pacific (MAP). In 2013-2016 the average incidence for Māori was 35% greater in Toi Te Ora compared to the average rate for Māori in New Zealand.

For Non-Māori, Asian and Pacific the incidence was 24% greater in Toi Te Ora compared to the average rate for Non-Māori, Asian and Pacific in New Zealand.

Figure 6: Serious skin Infection and ethnicity. Graph includes Non-MAP. Graph B includes Pacific and Asian

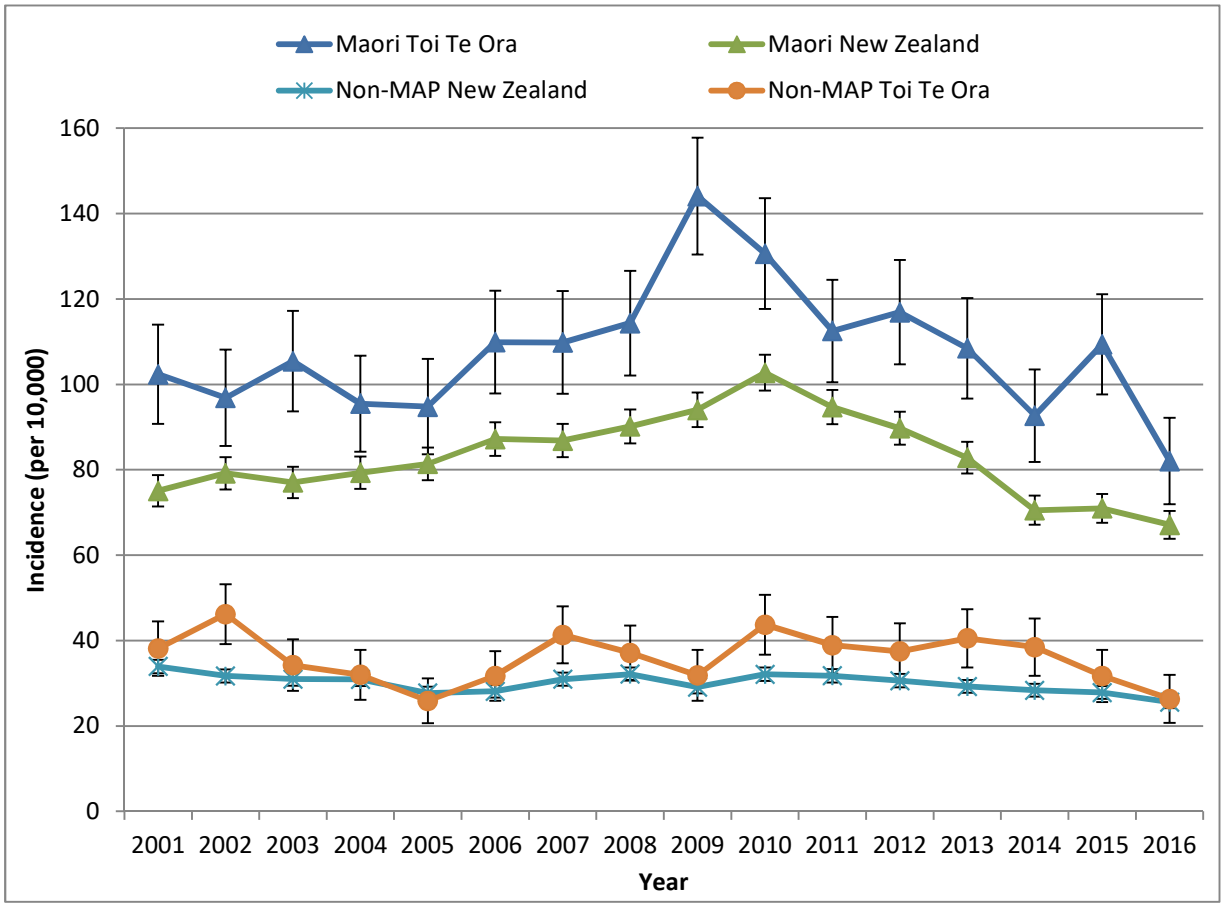




Māori and Non-Māori, Asian and Pacific

The 2016 incidence of serious skin infection in Māori is the lowest of the current time series in New Zealand and Toi Te Ora (Figure 7). The incidence in Toi Te Ora Māori is consistently larger than the incidence in New Zealand Māori. The difference has remained similar over the 15 year time series. The New Zealand and Toi Te Ora rates are statistically different. For the majority of the time series the Non-MAP incidence in Toi Te Ora has been greater than the average Non-MAP incidence for New Zealand. From 2014 to 2016 the incidence for Non-MAP in Toi Te Ora declined. In 2016 there was no difference between Non-MAP incident rates for Toi Te Ora and New Zealand.

Figure 7: Incidence of serious skin infection in Māori and Non-MAP



Māori and Non-Māori, Asian and Pacific by age group

Figure 8 displays the incidence of serious skin infection by age group and ethnicity for Māori and Non-MAP. In all age groups the rate in Māori is significantly higher than the rate in Non-MAP. Māori in the Toi Te Ora area have a higher incidence in all age groups compared to the average incidence for Māori in New Zealand. The incidence in the Toi Te Ora 0-4 age group Non-MAP ethnicity is not statistically different from the New Zealand rate. In the 5-9 and 10-14 age groups the Toi Te Ora Non-MAP rate is usually greater the than the New Zealand Non-MAP rate (Figure 8, Charts B and C).

Figure 8: Incidence of serious skin infection by ethnicity and age group

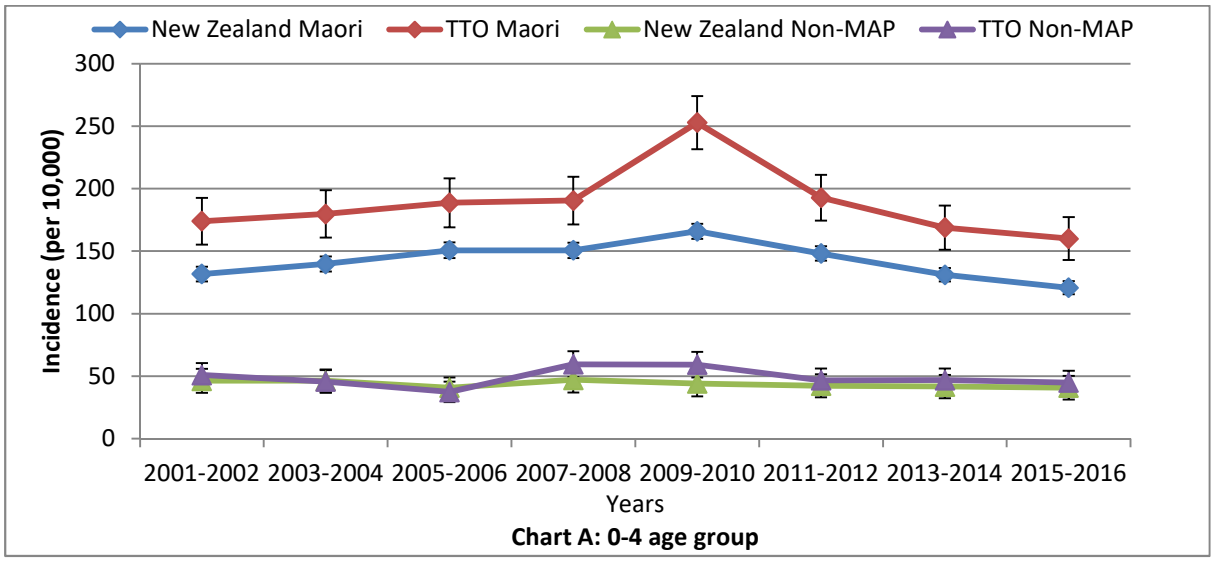


Chart A: 0-4 age group

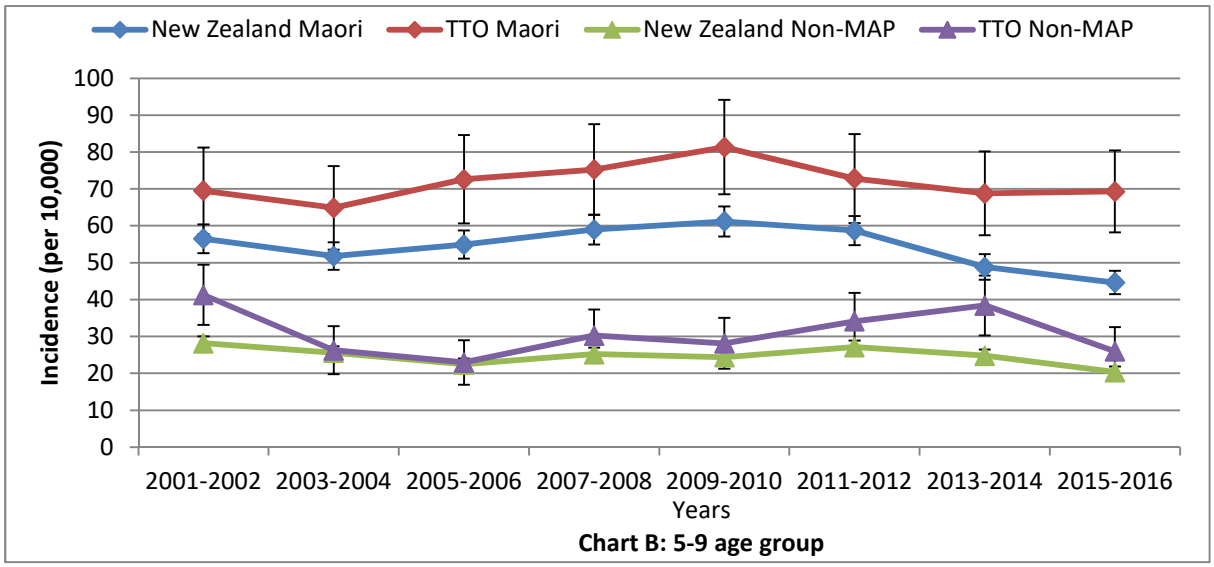


Chart B: 5-9 age group

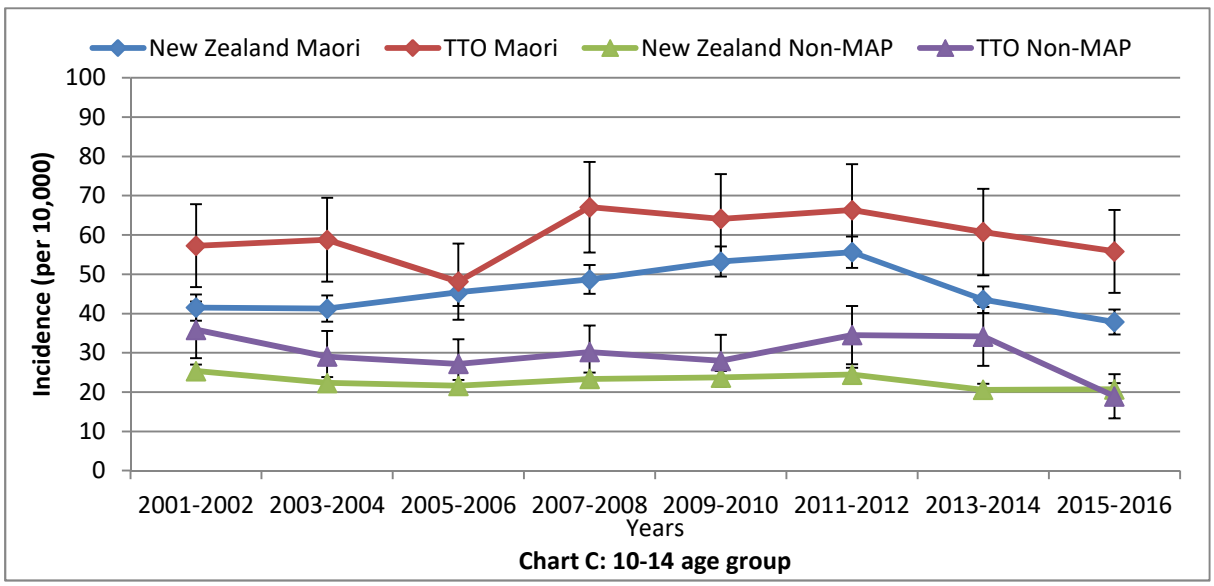


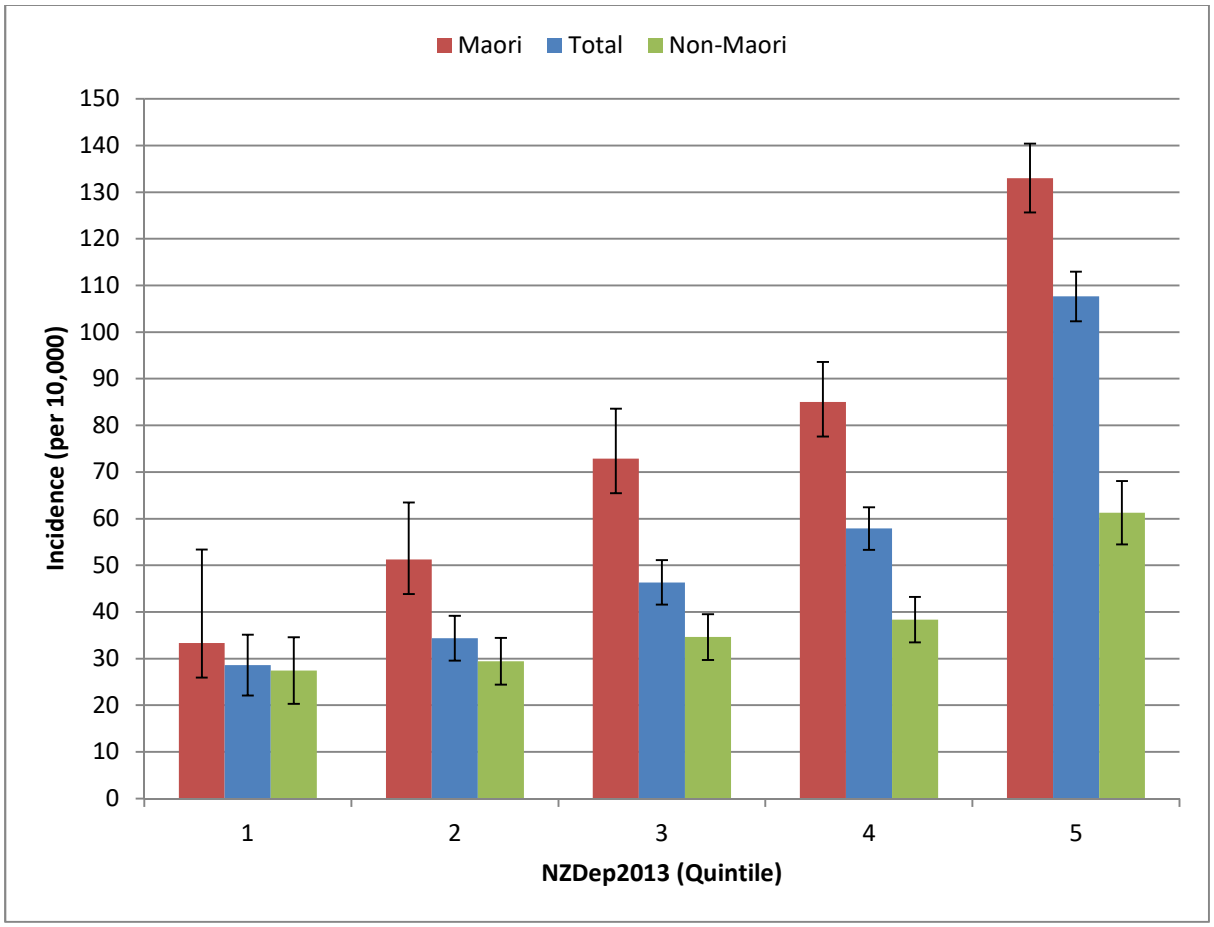
Chart C: 10-14 age group

3.1.5 Socioeconomic deprivation

Socioeconomic deprivation has been shown to be associated with serious skin infection (O'Sullivan et al, 2011). To investigate the incidence of serious skin infection by socioeconomic deprivation in the Toi Te Ora area the NZDep2013 CAU average quintile score was assigned to each case using the cases domicile code enabling the incidence for each deprivation quintile to be calculated. Due to the low number of cases in quintile one areas, multiple years of data were combined in order to calculate a rate in quintile one areas for the total population, Māori and Non-Māori. The confidence interval for the in incidence for Māori in quintile one areas uses the score (Wilson) method due to the low number of cases (Figure 9).

For the total population the incidence of serious skin infection increases as the deprivation quintile increases (Figure 9). When the data is divided into Māori and Non-Māori different patterns emerge. The incidence for quintile one areas is statistically the same for Māori and Non-Māori. However as the level of deprivation increases the incidence for Māori increases more than it does for Non-Māori. The NZDep2013 has a stronger correlation with the rate of skin infection for Māori than it does for Non-Māori.

Figure 9: Average incidence of serious skin infection by socioeconomic deprivation 2011-2016 in Toi Te Ora



3.2 Lakes DHB Summary

- The incidence of serious skin infection rose to a peak in 2009-2010 and has remained above 75 incident cases per 10,000 children to the end of the present time series.
- There have been changes in the category of incident cases. The rate Category A infection has declined slightly. The rates of Category B and D infections have remained constant. The rate of Category C skin infection has tripled over the time series.
- In Lakes DHB since 2011-2012 there has been no statistically significant difference between male and female. This is due to the incidence in females increasing from 2003-2004 until 2009-2010 as well a slight decline in the male incidence.
- Differences in the incidence between age groups have fluctuated over the time series without a pattern. The peak in the total incidence seen in 2009-2010 could be due to a peak in the 0-4 age group at the same time.
- Ethnic inequality between Māori and Non-MAP has not improved over the present time series.

	2001-2002			2003-2004			2005-2006			2007-2008			2009-2010			2011-2012			2013-2014			2015-2016		
	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio
Total	335	68.8 (61.5 - 76.2)		307	63.1 (56.0 - 70.1)		288	59.2 (52.4 - 66.0)		352	73.8 (66.1 - 81.6)		409	86.5 (78.1 - 94.8)		351	75.3 (67.4 - 83.2)		354	76.1 (68.1 - 84.0)		356	77.0 (69.0 - 85.0)	
Category																								
A	246	50.6 (44.2 - 56.9)		208	42.7 (36.9 - 48.6)		187	38.4 (32.9 - 43.9)		232	48.7 (42.4 - 54.9)		265	56.0 (49.3 - 62.8)		210	45.0 (39.0 - 51.1)		197	42.3 (36.4 - 48.2)		190	41.1 (35.3 - 47.0)	
B	20	4.1 (2.3 - 5.9)		17	3.5 (1.8 - 5.2)		20	4.1 (2.3 - 5.9)		14	2.9 (1.4 - 4.5)		20	4.2 (2.4 - 6.1)		14	3.0 (1.4 - 4.6)		23	4.9 (2.9 - 7.0)		17	3.7 (1.9 - 5.4)	
C	41	8.4 (5.8 - 11.0)		62	12.7 (9.6 - 15.9)		67	13.8 (10.5 - 17.1)		78	16.4 (12.7 - 20.0)		101	21.4 (17.2 - 25.5)		96	20.6 (16.5 - 24.7)		114	24.5 (20.0 - 29.0)		114	24.7 (20.1 - 29.2)	
D	28	5.8 (3.6 - 7.9)		20	4.1 (2.3 - 5.9)		14	2.9 (1.4 - 4.4)		28	5.9 (3.7 - 8.0)		23	4.9 (2.9 - 6.8)		31	6.6 (4.3 - 9.0)		20	4.3 (2.4 - 6.2)		35	7.6 (5.1 - 10.1)	
Gender																								
Male	182	72.9 (62.3 - 83.5)	1.13 (0.97 - 1.29)	184	73.7 (63.1 - 84.4)	1.42 (1.22 - 1.63)	150	60.1 (50.5 - 69.7)	1.03 (0.87 - 1.20)	213	87.1 (75.4 - 98.8)	1.45 (1.26 - 1.65)	228	94.0 (81.8 - 106.2)	1.20 (1.04 - 1.35)	172	71.8 (61.1 - 82.5)	0.91 (0.77 - 1.05)	189	79.0 (67.8 - 90.3)	1.08 (0.93 - 1.24)	188	79.3 (68.0 - 90.7)	1.06 (0.91 - 1.21)
Female	153	64.6 (54.3 - 74.8)	1.00	123	51.9 (42.7 - 61.1)	1.00	138	58.2 (48.5 - 67.9)	1.00	139	59.9 (49.9 - 69.8)	1.00	181	78.6 (67.1 - 90.0)	1.00	179	79.0 (67.4 - 90.5)	1.00	165	72.9 (61.8 - 84.0)	1.00	168	74.6 (63.3 - 85.9)	1.00
Age																								
0-4	173	110.8 (94.3 - 127.3)	2.26 (1.92 - 2.59)	167	106.9 (90.7 - 123.1)	2.66 (2.25 - 3.06)	165	105.6 (89.5 - 121.8)	3.50 (2.97 - 04.0)	188	118.2 (101.3 - 135.1)	2.33 (2.00 - 2.66)	258	159.2 (139.7 - 178.6)	3.81 (3.35 - 4.28)	216	133.7 (115.9 - 151.6)	3.03 (2.63 - 3.44)	206	133.2 (115.1 - 151.4)	2.89 (2.50 - 3.29)	202	135.5 (116.8 - 154.2)	3.74 (3.23 - 4.26)
5-9	79	48.9 (38.2 - 59.7)	1.00 (0.78 - 1.22)	72	44.6 (34.3 - 54.9)	1.11 (0.85 - 1.36)	72	44.6 (34.3 - 54.9)	1.48 (1.14 - 1.82)	82	52.6 (41.2 - 64.0)	1.04 (0.81 - 1.26)	85	55.6 (43.8 - 67.5)	1.33 (1.05 - 1.62)	68	44.5 (33.9 - 55.1)	1.01 (0.77 - 1.25)	77	49.1 (38.2 - 60.1)	1.07 (0.83 - 1.30)	99	61.5 (49.4 - 73.6)	1.70 (1.36 - 2.03)
10-14	83	49.1 (38.5 - 59.7)	1.00	68	40.2 (30.7 - 49.8)	1.00	51	30.2 (21.9 - 38.5)	1.00	82	50.7 (39.7 - 61.7)	1.00	66	41.7 (31.7 - 51.8)	1.00	67	44.1 (33.5 - 54.6)	1.00	71	46.1 (35.4 - 56.8)	1.00	55	36.2 (26.6 - 45.7)	1
Ethnicity																								
Maori	230	97.6 (85.0 - 110.2)	2.57 (2.23 - 2.90)	228	96.8 (84.2 - 109.3)	3.62 (3.15 - 4.09)	214	90.8 (78.7 - 103.0)	3.58 (3.10 - 4.06)	261	110.9 (97.4 - 124.3)	3.56 (3.13 - 3.99)	310	130.0 (115.5 - 144.4)	3.29 (2.93 - 3.66)	258	108.4 (95.2 - 121.7)	3.22 (2.83 - 3.62)	264	111.1 (97.7 - 124.5)	2.67 (2.35 - 2.99)	259	108.5 (95.3 - 121.8)	3.10 (2.72 - 3.48)
Non-MAP	84	38.0 (29.9 - 46.2)	1.00	59	26.7 (19.9 - 33.5)	1.00	56	25.4 (18.7 - 32.0)	1.00	66	31.1 (23.6 - 38.6)	1.00	81	39.5 (30.9 - 48.1)	1.00	67	33.6 (25.6 - 41.7)	1.00	80	41.6 (32.5 - 50.7)	1.00	65	35.0 (26.5 - 43.5)	1

Notes

1. f denotes the frequency of observations for the two year period.
2. The incidence represents an average rate for the two year period
3. All 95% confidence interval are normally distributed and unadjusted. Caution should be used when interpreting rates and accompanying confidence with fewer than 50 observations.
4. A rate ratio of 1.00 with no confidence interval denotes the arbitrary reference category

3.3 Bay of Plenty DHB

- The incidence of serious skin infection peaked in 2009-2010 and then declined to the lowest rate of the time series in 2015-2016.
- The greatest number of cases and highest rates are found in Category A. The incidence of Category A serious skin infection peaked in 2009-2010 and then declined to the lowest incidence of the time series in 2015-2016. The incidence of category C skin infection rose from the 2001-2002 period to the 2009-2010 period. At this point is had doubled. The incidence for category C infections has since fallen.
- In Bay of Plenty DHB a gender difference is present throughout the time series. Incident cases of serious skin infection are more likely to occur in male children compared to female children.
- The incidence for all age groups has reduced to the lowest level of the time series in 2015-2016.
- Ethnic based inequality has been present throughout the time series with some fluctuation without a disenable pattern. Both ethnic groupings have had the lowest incidence of the time series in 2015-2016.

Table 8: Serious skin infection Bay of Plenty DHB

	2001-2002			2003-2004			2005-2006			2007-2008			2009-2010			2011-2012			2013-2014			2015-2016		
	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio	f	Incidence (per 10,000)	Rate Ratio
Total	585	65.9 (60.6 - 71.3)		566	63.8 (58.5 - 69.0)		563	63.4 (58.2 - 68.7)		642	72.2 (66.6 - 77.7)		729	82.1 (76.2 - 88.1)		668	75.2 (69.5 - 80.9)		581	63.8 (58.6 - 69.0)		501	54.4 (49.6 - 59.2)	
Category																								
A	386	43.5 (39.2 - 47.8)		369	41.6 (37.3 - 45.8)		351	39.6 (35.4 - 43.7)		419	47.1 (42.6 - 51.6)		441	49.7 (45.0 - 54.3)		408	45.9 (41.5 - 50.4)		320	35.1 (31.3 - 39.0)		291	31.6 (28.0 - 35.2)	
B	47	5.3 (3.8 - 6.8)		27	3.0 (1.9 - 4.2)		28	3.2 (2.0 - 4.3)		26	2.9 (1.8 - 4.0)		30	3.4 (2.2 - 4.6)		26	2.9 (1.8 - 4.1)		40	4.4 (3.0 - 5.8)		26	2.8 (1.7 - 3.9)	
C	91	10.3 (8.1 - 12.4)		113	12.7 (10.4 - 15.1)		118	13.3 (10.9 - 15.7)		137	15.4 (12.8 - 18.0)		194	21.9 (18.8 - 24.9)		177	19.9 (17.0 - 22.9)		151	16.6 (13.9 - 19.2)		135	14.7 (12.2 - 17.1)	
D	61	6.9 (5.1 - 8.6)		57	6.4 (4.8 - 8.1)		66	7.4 (5.6 - 9.2)		60	6.7 (5.0 - 8.5)		64	7.2 (5.4 - 9.0)		57	6.4 (4.8 - 8.1)		70	7.7 (5.9 - 9.5)		49	5.3 (3.8 - 6.8)	
Gender																								
Male	354	77.6 (69.5 - 85.7)	1.45 (1.30 - 1.60)	328	71.9 (64.1 - 79.7)	1.30 (1.16 - 1.44)	327	71.7 (63.9 - 79.5)	1.31 (1.17 - 1.45)	365	79.7 (71.5 - 87.9)	1.24 (1.11 - 1.37)	396	86.5 (77.9 - 95.0)	1.12 (1.01 - 1.23)	361	78.9 (70.7 - 87.0)	1.11 (0.99 - 1.22)	338	72.1 (64.5 - 79.8)	1.31 (1.17 - 1.45)	286	60.6 (53.6 - 67.6)	1.26 (1.12 - 1.41)
Female	231	53.5 (46.6 - 60.5)	1.00	238	55.2 (48.2 - 62.2)	1.00	236	54.7 (47.7 - 61.7)	1.00	277	64.2 (56.6 - 71.7)	1.00	333	77.5 (69.2 - 85.8)	1.00	307	71.3 (63.3 - 79.3)	1.00	243	55.0 (48.1 - 61.9)	1.00	215	47.9 (41.5 - 54.3)	1.00
Age																								
0-4	289	105.9 (93.7 - 118.1)	2.55 (2.26 - 2.84)	300	109.9 (97.5 - 122.3)	2.59 (2.30 - 2.88)	300	109.9 (97.5 - 122.3)	2.89 (2.56 - 03.2)	357	125.7 (112.7 - 138.8)	2.89 (2.59 - 3.19)	452	153.6 (139.4 - 167.7)	3.54 (3.21 - 3.86)	352	117.4 (105.1 - 129.6)	2.32 (2.08 - 2.56)	282	94.8 (83.8 - 105.9)	2.09 (1.85 - 2.34)	268	91.0 (80.1 - 101.9)	2.55 (2.24 - 2.85)
5-9	164	55.3 (46.9 - 63.8)	1.33 (1.13 - 1.54)	131	44.2 (36.6 - 51.8)	1.04 (0.86 - 1.22)	142	47.9 (40.0 - 55.8)	1.26 (1.05 - 1.47)	149	50.8 (42.6 - 58.9)	1.17 (0.98 - 1.35)	145	50.1 (41.9 - 58.2)	1.15 (0.97 - 1.34)	164	56.9 (48.2 - 65.6)	1.12 (0.95 - 1.30)	160	52.2 (44.1 - 60.3)	1.15 (0.97 - 1.33)	124	38.6 (31.8 - 45.4)	1.08 (0.89 - 1.27)
10-14	132	41.5 (34.4 - 48.6)	1.00	135	42.5 (35.3 - 49.6)	1.00	121	38.1 (31.3 - 44.8)	1.00	136	43.6 (36.2 - 50.9)	1.00	132	43.4 (36.0 - 50.8)	1.00	152	50.6 (42.6 - 58.7)	1	139	45.3 (37.8 - 52.9)	1.00	109	35.7 (29.0 - 42.5)	1
Ethnicity																								
Maori	350	100.9 (90.3 - 111.5)	2.29 (2.05 - 2.54)	357	102.9 (92.3 - 113.6)	2.86 (2.57 - 3.16)	382	110.1 (99.1 - 121.2)	3.63 (3.27 - 4.00)	396	112.9 (101.8 - 124.0)	2.64 (2.38 - 2.90)	506	142.3 (129.9 - 154.7)	3.84 (3.51 - 4.18)	428	118.8 (107.6 - 130.1)	2.96 (2.68 - 3.24)	344	93.7 (83.8 - 103.6)	2.42 (2.17 - 2.68)	330	87.5 (78.0 - 96.9)	3.29 (2.93 - 3.64)
Non-MAP	219	44.0 (38.2 - 49.8)	1.00	179	35.9 (30.7 - 41.2)	1.00	151	30.3 (25.5 - 35.2)	1.00	211	42.7 (36.9 - 48.5)	1.00	179	37.0 (31.6 - 42.4)	1.00	190	40.1 (34.4 - 45.8)	1	182	38.7 (33.0 - 44.3)	1.00	122	26.6 (21.9 - 31.3)	1

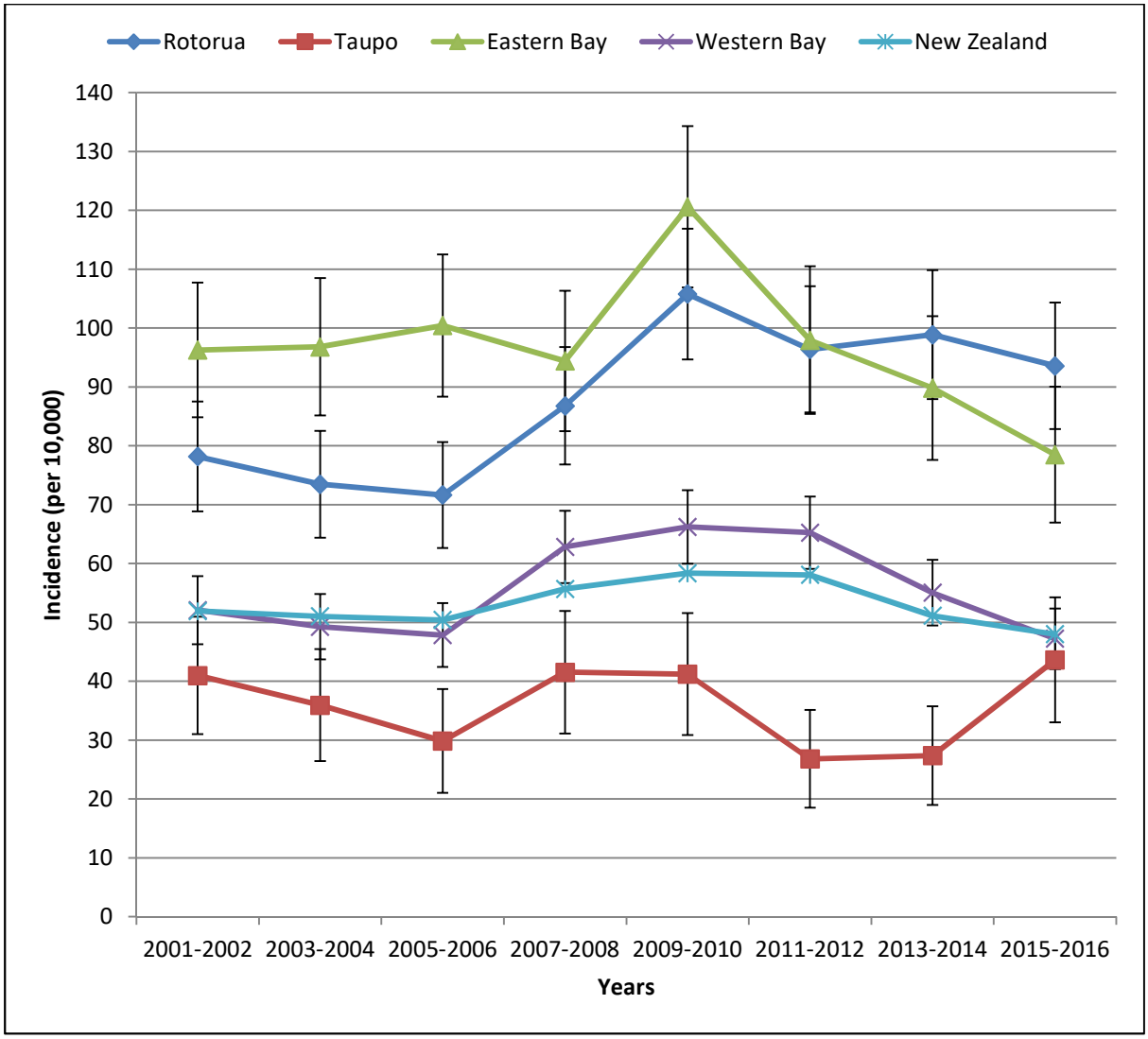
Notes

1. f denotes the frequency of observations for the two year period.
2. The incidence represents an average rate for the two year period
3. All 95% confidence interval are normally distributed and unadjusted. Caution should be used when interpreting rates and accompanying confidence with fewer than 50 observations.
4. A rate ratio of 1.00 denotes the arbitrary reference category

3.4 Sub-regions

The incidence of serious skin infection varies by the socioeconomic deprivation of different areas within Toi Te Ora. The higher deprivation sub-regions (Eastern Bay and Rotorua) have greater incidence of serious skin infection compared with the lower deprivation sub-regions (Western Bay of Plenty and Taupo). Eastern Bay displays a pronounced spike in the incidence of serious skin infections in 2009-2010. The rate in the Eastern Bay of Plenty has declined since the spike to the lowest recorded rate of the time series in 2015-2016. At the beginning of the time series Eastern Bay had a higher incidence than Rotorua. In the last two periods of the series Eastern Bay has a lower incidence than Rotorua. The lower incidence for Eastern Bay compared with Rotorua in 2015-16 is not statistically significant (two tailed z-test, p=0.064).

Figure 10: Incidence of serious skin infection in the sub-regions of Toi Te Ora



3.5 Small geographic areas - census area units

Census area units (CAUs) are small geographical areas created for the census. CAUs in urban areas are similar to the areas commonly recognised as suburbs and often have a similar name to the corresponding suburb. Table 7 shows the twenty CAUs with the highest number of incident cases. In the later time period compared to the earlier time period the maximum (2014-2016: 52 and 2011-2013: 61) and mean number of cases (2014-2016: 27 and 2011-2013: 31) have both reduced. In 2014-2016 CAUs in Lakes DHB featured with greater prominence than they did in 2011-2013. In 2011-2013 six of the twenty CAUs were from Lakes this increased to eight CAUs. In 2011-2013 one CAU out of the five with the highest number of case was from Lakes DHB. In 2014-2016 this number increased to three out of five. Appendix 3 includes the number of cases for all CAUs in Toi Te Ora.

Table 9: The 20 census area units with the highest number of incident cases of serious skin infection. Blue rows represent Lakes DHB and Red Rows represent Bay of Plenty DHB.

2011-2013				2014-2016			
DHB	**Local Authority**	**CAU**	**Incident cases**	**DHB**	**Local Authority**	**CAU**	**Incident cases**
BOP	Kawerau	Kawerau	61	Lakes	Rotorua	Western Heights	52
Lakes	Rotorua	Western Heights	50	BOP	Kawerau	Kawerau	39
BOP	Western BOP	Te Puke East	39	Lakes	Rotorua	Fordlands	36
BOP	Whakatane	Whakatane North	39	Lakes	Rotorua	Pukehangi North	34
BOP	Tauranga	Yatton Park	37	BOP	Tauranga	Yatton Park	30
BOP	Whakatane	Urewera	31	BOP	Whakatane	Trident	30
BOP	Tauranga	Gate Pa	30	BOP	Opotiki	Opotiki	30
Lakes	Rotorua	Owhata West	30	BOP	Tauranga	Gate Pa	27
Lakes	Rotorua	Fordlands	29	Lakes	Rotorua	Owhata West	27
BOP	Whakatane	Trident	28	BOP	Western BOP	Te Puke East	25
Lakes	Rotorua	Mangakakahi	28	BOP	Tauranga	Welcome Bay East	24
Lakes	Rotorua	Kuirau	28	BOP	Tauranga	Hairini	23
BOP	Opotiki	Opotiki	27	BOP	Tauranga	Brookfield	23
BOP	Tauranga	Hairini	27	Lakes	Rotorua	Selwyn Heights	23
BOP	Whakatane	Whakatane West	26	Lakes	Rotorua	Mangakakahi	22
BOP	Whakatane	Murupara	26	BOP	Tauranga	Tauranga Central	22
BOP	Tauranga	Greerton	26	BOP	Whakatane	Whakatane West	21
Lakes	Rotorua	Pukehangi North	23	BOP	Whakatane	Murupara	20
BOP	Tauranga	Tauranga Central	23	Lakes	Taupo	Turangi	20
BOP	Tauranga	Arataki	12	Lakes	Rotorua	Koutu	18

4 Conclusions/findings

The following section presents the key findings of the analysis of serious skin infection in the Toi Te Ora area:

- The incidence of serious skin infection in Toi Te Ora has declined since a peak in the rate in 2009 and 2010.
- The lowest incidence for Toi Te Ora of the 2001-2016 time series occurred in 2016.
- Historically the Bay of Plenty DHB and Lakes DHB have displayed a similar incidence of serious skin infection. The rates have diverged and the rate in Bay of Plenty DHB is approaching the average rate for New Zealand. The rate in Lakes DHB has remained high compared to the average New Zealand rate. The divergence is not due to ethnic demographic differences between Lakes DHB and Bay of Plenty DHB. The divergence remains when the data is analysed using only Māori admissions.
- Serious skin infection is divided in into four categories. In Toi Te Ora the rate of skin infection of typical sites (category A) has reduced to the lowest level of the time series. However category A still accounts for the majority of serious skin infection cases, this is because it comprises codes from the ICD10 skin sub-chapter. The rate of skin infection secondary to a primary disease of the skin (category C) increased over the time period investigated. Within Toi Te Ora the rate of category C serious skin infection has doubled from 16 per 10,000 children in 2001 to 32 per 10,000 children in 2016.
- When the categories were broken down into the specific conditions and the 2011-2013 time period was compared to 2014-2016, most conditions saw a reduction in the number of cases and there were no large increases for any of the included conditions. The largest reduction in the number of cases was in scabies. In 2011-2013 there were 85 cases and in 2014-2016 just 34 cases.
- The incidence changes according to age. The rate of serious skin infection is highest in the 0-4 age group and lowest in the 10-14 age group. Within each age group the rate in Toi Te Ora is greater than the average New Zealand rate. The analysis of single year age grouping found the highest rates of skin infection are in children aged zero to two years old. From 4 years old to 14 years old the rates are similar. At every single year age grouping the rate for Toi Te Ora is greater than the average New Zealand rate.
- In Toi Te Ora and New Zealand there are large inequalities in the rate of serious skin infection between ethnic groups. Within Toi Te Ora Māori and Pacific children have the highest rates of serious skin infection. Māori in Toi Te Ora have a higher rate than the average New Zealand rate for Māori. Non-Māori, Asian and Pacific (MAP) children have a higher rate than the average rate for New Zealand. The inequality between Maori and Non-MAP from 2001 to 2016 has fluctuated and has not been reduced for a sustained period of time.
- In the three age groups (0-4, 5-9, 10-14), Māori children have a higher rate of serious skin infection compared to Non-MAP children. The rate in Toi Te Ora Māori for the three age groups is higher than the same rates for New Zealand Māori.
- There is a socioeconomic gradient for rate of serious skin infection. The gradient is stronger for Māori children than it is for Non-Māori children.
- When Toi Te Ora is broken down into smaller geographic areas the highest rates of serious skin infection are found in Rotorua. Historically the highest rates have been found in Eastern Bay of

Plenty however the rate has reduced in Eastern Bay of Plenty while the rates in Rotorua have remained high.

Appendices

Appendix 1: Literature scan

The following provides a bibliography of New Zealand based skin infection literature produced from 2015 to May 2018. Excerpts or a brief summary are provided. The papers are present in chronological order.

New Zealand Skin Infection literature 2015 - May 2018
Continued from:
https://www.ttophs.govt.nz/vdb/document/1591

Colonisation with Staphylococcus aureus and Streptococcus pyogenes in New Zealand preschool children

The colonisation rates of two common bacterial causes of skin infection were investigated by this study. Swabs were collected from 139 four year old children. 54% were colonised with Staphylococcus aureus and 16% were colonised with Streptococcus pyogenes.

Berry, S., Morton, S., Atatoa Carr, P., Marks, E., Ritchie, S., Upton, A., ... & Grant, C. (2015). Colonisation with Staphylococcus aureus and Streptococcus pyogenes in New Zealand preschool children. *NZ Med J*, *128*(1410), 60-7.

Maintaining the balance: New Zealand secondary school nurses' perceptions of skin infections in young people – a grounded theory

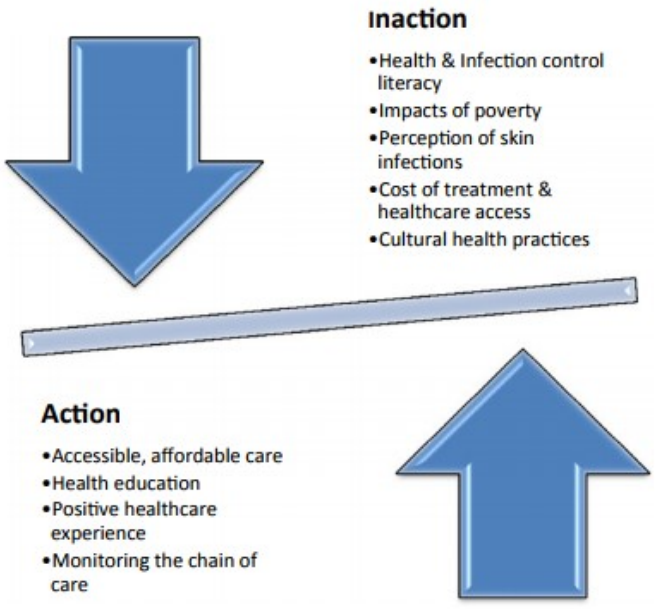


Figure 2 Maintaining the balance.

"Figure 2 is used to illustrate the theory 'Maintaining the balance'. It represents the constant state of balancing the school nurse undergoes to counter the risk to the student and barriers to treatment within the community.

The nurse attempts to tip the balance in favour of action, by reducing barriers to healthcare, providing youth-friendly and accessible healthcare which is affordable, and providing follow-up until resolution is achieved. The nurse is aware that failing to monitor the student until the skin infection has resolved can again tip the fulcrum back to inaction, placing the young person at risk once again."

Lambe, C. I., & Hoare, K. J. (2016). Maintaining the balance: New Zealand secondary school nurses' perceptions of skin infections in young people–a grounded theory. *Health & social care in the community*, *24*(1), 105-112.

Where to from here? The treatment of impetigo in children as resistance to fusidic acid emerges.

This paper discusses concern over antimicrobial resistance to fusidic acid in community acquired S. aureus skin and soft tissue infections. There is uncertainty about the effectiveness of other treatments including oral antibiotic for the treatment of impetigo. However an upcoming RCT will be comparing hydrogen peroxide cream, fusidic acid and 'clean and cover'.

Vogel, A., Lennon, D., Best, E., & Leversha, A. (2016). Where to from here? The treatment of impetigo in children as resistance to fusidic acid emerges. *NZ Med J*, *129*(1443), 77.

Nurse-led school-based clinics for rheumatic fever prevention and skin infection management: evaluation of Mana Kidz programme in Counties Manukau

"Mana Kidz is an important and effective school-based health programme that is making a substantial contribution to healthcare for more than 24,000 children across 61 schools in South Auckland. The service includes identification and treatment of sore throats to prevent rheumatic fever, identification and management of skin infections, identification of other health needs such as hearing, vision or child protection concerns. An evaluation was undertaken that demonstrated that the service a) increased health literacy, b) reduced prevalence of Group A Streptococcus and severe skin infections, c) likely to have significantly reduced hospitalisations for acute rheumatic fever, d) increased children and whānau engagement with health services, and e) has a workforce that is culturally competent with positive, trusting relationships with children, families and schools. The evaluators concluded that Mana Kidz makes a significant difference to children's health and that it is an important and effective programme that is making a substantial contribution to healthcare for vulnerable children"

Anderson, P., King, J., Moss, M., Light, P., McKee, T., Farrell, E., ... & Lennon, D. (2016). Nurse-led school-based clinics for rheumatic fever prevention and skin infection management: evaluation of Mana Kidz programme in Counties Manukau. *NZ Med J*, *129*(1428), 36-45.

Antimicrobial stewardship using pharmacy data for the nurse-led school-based clinics in Counties Manukau District Health Board for management of group A streptococcal pharyngitis and skin infection

"Antimicrobial dispensing data sampled from pharmacies participating in the programme show that the antimicrobial prescribing pattern is conservative and well complies with the operating guidelines. There was very limited use of second-line antimicrobials for recurrent pharyngitis, and repeating exposure per person is uncommon. This audit provides affirmation that antimicrobials are used in an efficient and judicious way in the programme."

Tsai, J. Y. C., Anderson, P., Broome, L., McKee, T., & Lennon, D. (2016). Antimicrobial stewardship using pharmacy data for the nurse-led school-based clinics in Counties Manukau District Health Board for management of group A streptococcal pharyngitis and skin infection. *JIA*, *129*(1435).

The rise and fall of hospitalizations for skin infections in New Zealand, 2004–2014: trends by ethnicity and socioeconomic deprivation

National skin infection rates rose peaked in 2011 and declined until 2014. A decline in high risk child hospitalization rates was observed. Ethnic inequalities still persist.

Lim, A., Rumball-Smith, J., Jones, R., & Kawachi, I. (2017). The rise and fall of hospitalizations for skin infections in New Zealand, 2004–2014: trends by ethnicity and socioeconomic deprivation. *Epidemiology & Infection*, *145*(4), 678-684.

Ethnic disparities in infectious disease hospitalisations in the first year of life in New Zealand

This study identifies risk factors associated with infectious disease hospitalisation in the first year of life in New Zealand. Risk factors are investigated for Maori and Pacific children.

"In the whole cohort, factors associated with ID hospitalisation were Māori (OR: 1.49, 95% CI: 1.17–1.89) or Pacific (2.51; 2.00–3.15) versus European maternal ethnicity, male gender (1.32; 1.13–1.55), low birthweight (1.94, 1.39–2.66), exclusive breastfeeding for <4 months (1.22, 1.04–1.43), maternal experience of health-care racism (1.60, 1.19–2.12), household deprivation (most vs. least deprived quintile of households (1.50, 1.12–2.02)), day-care attendance (1.43, 1.12–1.81) and maternal smoking (1.55, 1.26–1.91).

Factors associated with ID hospitalisation for Māori infants were high household deprivation (2.16, 1.06–5.02) and maternal smoking (1.48, 1.02–2.14); and for Pacific infants were delayed immunisation (1.72, 1.23–2.38), maternal experience of health-care racism (2.20, 1.29–3.70) and maternal smoking (1.59, 1.10–2.29)."

Hobbs, M. R., Morton, S., Atatoa-Carr, P., Ritchie, S. R., Thomas, M. G., Saraf, R., ... & Grant, C. C. (2017). Ethnic disparities in infectious disease hospitalisations in the first year of life in New Zealand. *Journal of paediatrics and child health*, 53(3), 223-231.

Scabies is strongly associated with acute rheumatic fever in a cohort study of Auckland children

"A recent diagnosis of scabies from hospital records is strongly associated with a subsequent diagnosis of ARF. Further investigation of the role that scabies infestation may play in the aetiology of ARF is warranted."

Thornley, S., Marshall, R., Jarrett, P., Sundborn, G., Reynolds, E., & Schofield, G. (2018). Scabies is strongly associated with acute rheumatic fever in a cohort study of Auckland children. *Journal of paediatrics and child health*.

Staphylococcus aureus Carriage in a New Zealand Primary School: A Cohort Study

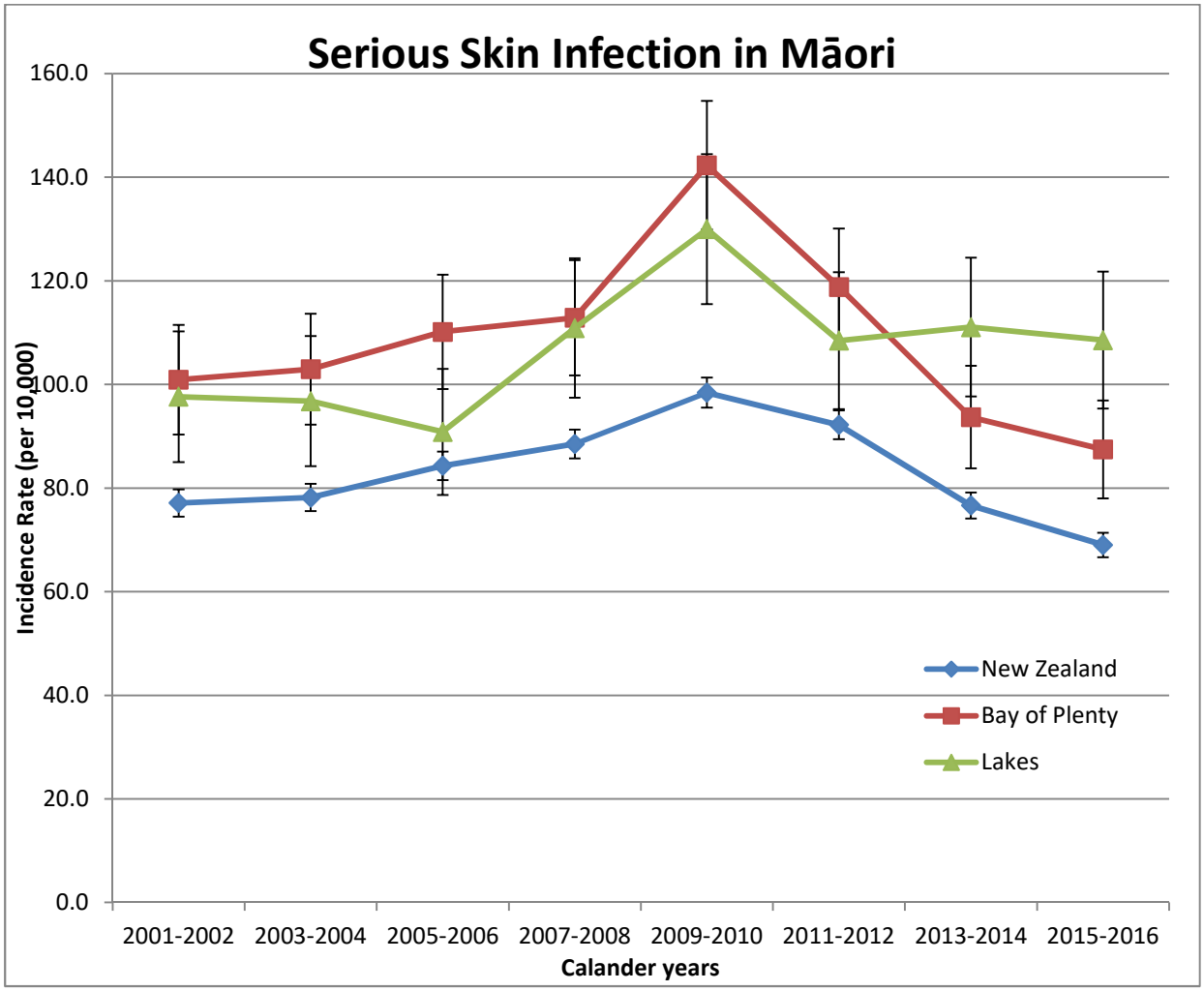
Abstract: Asymptomatic carriage of Staphylococcus aureus is a source of transmission between healthy individuals. Seventy children at a primary school were swabbed 7 times to identify patterns of S. aureus carriage. S. aureus carriage prevalence was 53%–65% at each round and 45% carried at every round. High carriage prevalence may indicate that school-aged children are important contributors to S. aureus transmission.

Scott, P., Priest, P. C., Chambers, S. T., Heijne, J. C., & Murdoch, D. R. (2018). Staphylococcus aureus Carriage in a New Zealand Primary School: A Cohort Study. *The Pediatric infectious disease journal*, *37*(6), e172-e175.

Appendix 2: Toi Te Ora counts of incident cases of serious skin infection

Year	Total	Category				Age Group			Gender		Ethnicity			
		A	B	C	D	0-4	5-9	10-14	F	M	Māori	Asian	Pacific	Non-MAP
2001	450	301	30	72	47	246	112	92	187	263	298	2	13	137
2002	470	331	37	60	42	216	131	123	197	273	282	6	16	166
2003	453	299	19	93	42	253	104	96	201	252	307	4	19	123
2004	420	278	25	82	35	214	99	107	160	260	278	7	20	115
2005	392	244	24	84	40	193	109	90	168	224	276	8	15	93
2006	459	294	24	101	40	272	105	82	206	253	320	13	12	114
2007	493	335	18	105	35	253	116	124	210	283	321	2	23	147
2008	501	316	22	110	53	292	115	94	206	295	336	6	29	130
2009	569	373	22	123	51	353	120	96	261	308	427	8	24	110
2010	569	333	28	172	36	357	110	102	253	316	389	9	21	150
2011	500	316	15	137	32	279	110	111	248	252	336	8	24	132
2012	519	302	25	136	56	289	122	108	238	281	350	15	29	125
2013	489	257	41	146	45	273	120	96	211	278	326	7	20	136
2014	446	260	22	119	45	215	117	114	197	249	282	11	27	126
2015	479	261	25	139	54	256	129	94	201	278	335	13	28	103
2016	378	220	18	110	30	214	94	70	182	196	254	17	23	84

Appendix 3: Comparison of the two DHBs and New Zealand of the incidence of serious skin infection in Māori children aged 0-14 years old.



The table below displays the two tailed z test p-value for a comparison of the rate in Lakes and Bay of Plenty Maori children. The results show the that the rate of serious skin infection in Maori children has reduced in the Bay of Plenty DHB while the rate has remained constant in Lakes DHB and that there is now a statistically significant difference between Lakes DHB and Bay of Plenty DHB.

Calendar years	2-tail z-test p-values
2013-14	0.02
2015-16	0.01

Appendix 4: Small geographic areas (census area units)

The following table presents the number of cases of serious skin infection in each census area unit. The census area units are ordered on the number of cases in 2014-2016. There is a table for each local authority area.

District	Census Area Unit	2011-2013	2014-2016
Kawerau	Kawerau	61	39

District	Census Area Unit	2011-2013	2014-2016
Opotiki	Opotiki	27	30
Opotiki	Waiotahi	10	7
Opotiki	Cape Runaway	5	4
Opotiki	Oponae	1	2
Opotiki	Te Kaha	0	1

District	Census Area Unit	2011-2013	2014-2016
Western BOP	Te Puke East	39	25
Western BOP	Te Puke West	14	17
Western BOP	Te Puna	8	17
Western BOP	Kaimai	15	13
Western BOP	Rangiuru	11	11
Western BOP	Minden	21	10
Western BOP	Pongakawa	9	9
Western BOP	Katikati Community	15	8
Western BOP	Aongatete	9	8
Western BOP	Maketu Community	5	8
Western BOP	Omokoroa	4	5
Western BOP	Ohauiti - Ngapeke	2	5
Western BOP	Upper Papamoa	2	5
Western BOP	Paengaroa	9	4
Western BOP	Matakana Island	3	4
Western BOP	Tahawai	3	2
Western BOP	Athenree	1	1
Western BOP	Island View - Pios Beach	1	1
Western BOP	Waihi Beach	2	0

District	Census Area Unit	2011-2013	2014-2016
Whakatane	Trident	28	30
Whakatane	Whakatane West	26	21
Whakatane	Murupara	26	20
Whakatane	Whakatane North	39	16
Whakatane	Urewera	31	15
Whakatane	Allandale - Mokorua	18	14
Whakatane	Matahina - Minginui	7	14
Whakatane	Taneatua	19	8
Whakatane	Rotoma	7	8
Whakatane	Otakiri	15	7
Whakatane	Te Teko	5	7
Whakatane	Waimana	8	5
Whakatane	Edgecumbe	7	5
Whakatane	Ohope	2	3
Whakatane	Poroporo	2	3
Whakatane	Coastlands	4	2
Whakatane	Orini	4	2
Whakatane	Matata	3	2

District	Census Area Unit	2011-2013	2014-2016
Taupo	Turangi	11	20
Taupo	Taupo Central	4	18
Taupo	Tauhara	9	12
Taupo	Oruanui	4	7
Taupo	Hilltop	2	6
Taupo	Mangakino	4	4
Taupo	Broadlands	0	3
Taupo	Iwitahi	5	2
Taupo	Lakewood	4	2
Taupo	Richmond Heights	4	2
Taupo	Nukuhau	3	2
Taupo	Marotiri	2	2
Taupo	Waipahihi	1	2
Taupo	Wairakei - Aratiatia	0	2
Taupo	Kuratau	2	1
Taupo	Motuoapa	0	1
Taupo	Kinloch	2	0
Taupo	Rangatira	1	0
Taupo	Rangipo	1	0
Taupo	Wharewaka	1	0

District	Census Area Unit	2011-2013	2014-2016
Rotorua	Western Heights	50	52
Rotorua	Fordlands	29	36
Rotorua	Pukehangi North	23	34
Rotorua	Owhata West	30	27
Rotorua	Selwyn Heights	17	23
Rotorua	Mangakakahi	28	22
Rotorua	Koutu	21	18
Rotorua	Glenholme West	19	18
Rotorua	Ngongotaha North	19	17
Rotorua	Hillcrest	18	17
Rotorua	Kuirau	28	16
Rotorua	Pukehangi South	11	15
Rotorua	Tikitere	20	12
Rotorua	Owhata East	12	12
Rotorua	Fairy Springs	12	11
Rotorua	Kawaha Point	11	11
Rotorua	Sunnybrook	15	10
Rotorua	Utuhina	9	8
Rotorua	Victoria	17	7
Rotorua	Ngongotaha South	11	7
Rotorua	Lynmore	12	6
Rotorua	Fenton	9	6
Rotorua	Pomare	4	6
Rotorua	Mamaku	2	5
Rotorua	Ngapuna	1	5
Rotorua	Golden Springs	6	4
Rotorua	Owhata South	4	4
Rotorua	Tarawera	4	4
Rotorua	Springfield	10	3
Rotorua	Hamurana	5	3
Rotorua	Ngakuru	5	3
Rotorua	Kaingaroa Forest	4	3
Rotorua	Waiwhero	1	3
Rotorua	Poets Corner	0	3
Rotorua	Whaka	6	1
Rotorua	Glenholme East	3	1
Rotorua	Ohinemutu	2	1
Rotorua	Reporoa	2	1

District	Census Area Unit	2011-2013	2014-2016
Tauranga	Yatton Park	37	30
Tauranga	Gate Pa	30	27
Tauranga	Welcome Bay East	14	24
Tauranga	Hairini	27	23
Tauranga	Brookfield	17	23
Tauranga	Tauranga Central	23	22
Tauranga	Mt Maunganui North	13	18
Tauranga	Palm Springs	4	15
Tauranga	Arataki	22	12
Tauranga	Greerton	26	11
Tauranga	Matua	14	11
Tauranga	Doncaster	10	11
Tauranga	Welcome Bay West	19	10
Tauranga	Tauranga Hospital	16	10
Tauranga	Judea	13	9
Tauranga	Tauranga South	8	9
Tauranga	Maungatapu	4	9
Tauranga	Pyes Pa	19	8
Tauranga	Te Maunga	18	7
Tauranga	Te Reti	9	7
Tauranga	Poike	4	7
Tauranga	Gravatt	7	6
Tauranga	Otumoetai North	6	6
Tauranga	Otumoetai South	6	6
Tauranga	Pacific View	3	6
Tauranga	Bethlehem East	2	6
Tauranga	Bellevue	20	5
Tauranga	Palm Beach	11	5
Tauranga	Papamoa Beach East	7	5
Tauranga	Kaitemako	3	5
Tauranga	Matapihi	3	5
Tauranga	Bethlehem	13	2
Tauranga	Omanu	10	2
Tauranga	Kairua	2	2

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