INVASIVE GROUP A STREPTOCOCCAL INFECTION IN NEW ZEALAND, 2014 AND 2015

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ABBREVIATIONS

Abbreviation	Description
CANVAS	Coalition to Advance New Vaccines Against Group A *Streptococcus*
DHB	District health board
DNA	Deoxyribonucleic acid
emm	M protein gene
ESR	Institute of Environmental Science & Research Ltd.
GAS	Group A *Streptococcus*
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification
MELAA	Middle Eastern, Latin American or African ethnic group
NHI	National Health Index
NMDS	National minimum data set (hospital discharges)
NZDep2013	New Zealand index of deprivation 2013
PCR	Polymerase chain reaction

SUMMARY

Invasive group A streptococcal (GAS) infections are uncommon but serious, with a high mortality rate. Globally, and in New Zealand, invasive GAS infections have been noted to be increasing over the last decade or more [1]. From 2002 to 2012 invasive GAS infection rates in New Zealand increased from 3.9 per 100,000 population to 7.9 per 100,000 and remain about twice that reported in other high-income countries [2].

Invasive GAS infection is not a notifiable condition in New Zealand. Consequently, surveillance of invasive GAS infection is predominantly passive and laboratory-based, and depends on individual laboratories sending clinically relevant GAS isolates to the Institute of Environmental Science and Research (ESR) for further typing.

This is the first report on the epidemiology of invasive GAS infections in New Zealand. The report is based on laboratory data and presents summary information on invasive GAS isolates referred to ESR in 2014 and 2015.

Invasive GAS infection rates in New Zealand were 7.2 per 100,000 population in 2014 and 7.5 cases per 100,000 population in 2015—a decrease since a peak of 9.3 cases per 100,000 in 2011 [2]. Patterns of invasive GAS infection in 2014 and 2015 are consistent with other reports, including high rates in the very young and the very old, higher rates among those more socioeconomically deprived, and ethnic differences [1] with higher rates among Māori and Pacific peoples compared to European or Other ethnicities [2]. In New Zealand invasive GAS infection is most common in summer, which is in contrast to other high income countries in the northern hemisphere which report winter/spring peaks [3, 4].

Molecular *emm* typing for isolates in 2014 and 2015 revealed that *emm* type 1 was most common, as reported in previous years [2]. However, the other most common *emm* types in 2014 and 2015 were different from previous years, highlighting the diversity in circulating *emm* types each year. The leading candidate GAS 30-valent vaccine, which has just completed phase I trials, could have provided protection for up to 54% of invasive GAS cases in 2014 and 2015—depending on vaccine efficacy and coverage. Theoretical protection from the vaccine could potentially increase to about 70% of cases being prevented if cross-opsonisation (cross-protection) is taken into account. The proposed 30-valent vaccine would have protected against six of the seven most common *emm* types circulating in 2014 and 2015 [5, 6].

Continued surveillance of invasive GAS infection and laboratory molecular typing of isolates will be important to monitor trends in New Zealand.

INTRODUCTION

Group A *Streptococcus* (GAS) can cause both invasive disease (necrotising fasciitis, streptococcal toxic shock syndrome, cellulitis, bacteraemia, pneumonia, puerperal sepsis) and non-invasive disease (pharyngitis, impetigo, superficial skin infections). In addition, there are non-suppurative immunologic sequelae of GAS infections including acute rheumatic fever, rheumatic heart disease, scarlet fever and post streptococcal glomerulonephritis. Rheumatic heart disease is a leading cause of acquired heart disease in young people worldwide. Together GAS diseases account for considerable mortality and morbidity in New Zealand [2, 7].

People with an increased risk for invasive GAS disease include those with chronic conditions such as cancer, diabetes, obesity, and chronic heart or lung disease, and those with compromised immune systems [7, 8]. People with skin lesions, the elderly, and adults with a history of alcohol abuse or injecting drug use also have increased risk of invasive GAS disease [9].

Invasive GAS infection is not a notifiable condition in New Zealand. Consequently, surveillance of invasive GAS infection is predominantly passive and laboratory-based, and depends on individual laboratories sending clinically relevant GAS isolates to the Institute of Environmental Science and Research (ESR) for further typing. Laboratories throughout New Zealand have been sending invasive GAS isolates to ESR for over 20 years. M protein gene (*emm*) typing conducted at ESR is important for identifying outbreaks of invasive GAS infection and to assess the potential impact of a vaccine on disease incidence in New Zealand.

A national population-based study reviewing invasive GAS disease from 2002 to 2012 in New Zealand was published in 2014 by Williamson *et al.* using ESR laboratory molecular typing data and Ministry of Health hospitalisation and mortality data [2]. This report provides an update on invasive GAS disease in New Zealand for 2014 and 2015. The report presents summary information on invasive GAS isolates received by the Invasive Pathogens Laboratory at ESR in 2014 and 2015.

METHODS

SURVEILLANCE METHODS

Surveillance of invasive GAS infection is laboratory-based, and relies on individual laboratories sending clinically relevant GAS isolates for further typing. These isolates are sent to the Invasive Pathogens Laboratory at ESR for *emm* typing. The numbers presented in this report are therefore likely to undercount the true burden of disease in New Zealand.

The following data is collected about each patient who has an isolate sent for typing: National Health Index (NHI) number, age, sex, specimen type (blood, wound, tissue etc.), symptoms and date specimen collected. Symptoms were not well described. Ethnicity data was provided for only 25% of cases where an isolate was received. Additional data (date of birth, date of death, sex, ethnicity, and domicile code) was obtained from NHI records held by the Ministry of Health and was matched with the laboratory data. Domicile codes were mapped to district health board (DHB) and the New Zealand index of deprivation 2013 (NZDep2013) [10].

In addition, hospital discharge data was obtained from the Ministry of Health from the National Minimum Dataset (NMDS). Information from laboratory isolates was matched with hospital discharges by the NHI where the specimen collection date was between the admission and discharge date. New Zealand hospitals use the ICD-10-AM clinical coding classification, developed by the World Health Organization and modified by the National Centre for Classification in Health, Australia.

LABORATORY METHODS

Identification of GAS isolates was carried out at individual laboratories prior to specimens being sent to ESR. At ESR molecular typing was performed by polymerase chain reaction (PCR) and deoxyribonucleic acid (DNA) sequencing of the *emm* gene. These methods are described in full by Beall *et al.* [11].

ANALYTICAL METHODS

Case definition

An invasive GAS infection was defined as one in which GAS was isolated from a normally sterile body site (e.g., blood, cerebrospinal fluid, pleural fluid, synovial fluid) or where necrotising fasciitis was recorded in the symptoms field. This definition is consistent with the Centers for Disease Control and Prevention definition for surveillance of GAS [12]. Where the sample site was unknown, the infection was classified as invasive if one or more of the following ICD-10-AM codes was specified in the hospital discharge diagnoses: A40.0, sepsis due to streptococcus, group A; A48.3, toxic shock syndrome; M72.6, necrotising fasciitis; or O85 puerperal sepsis.

30-day mortality was defined as a date of death within 30 days of the laboratory sample being collected or, if a sample date was not provided, within 30 days of receipt of the sample at ESR.

Dates

Data in this report is based on isolates received by ESR in 2014 and 2015. Data was extracted from the laboratory information system for 2014 records on 3 February 2015 and for 2015 records on 9 March 2016. Laboratory information was matched with NHI data that was extracted on 3 September 2015 (for 2014 records) and 26 April 2016 (for 2015), and with NMDS data on 15 February 2016 (for 2014 records) and 26 April 2016 (for 2015).

Population rate calculations

The denominator data used to determine disease rates, except the rates for ethnic groups and deprivation, was from the 2014 and 2015 mid-year population estimates published by Statistics New Zealand. All rates are presented as the number of cases per 100,000 population. Rates have not been reported where there were fewer than five cases in any category. Calculating population rates from fewer than five cases produces unstable rates.

Ethnicity

Ethnicity is prioritised in the following order: Māori, Pacific peoples, Asian, Middle Eastern/Latin American/African (MELAA), and European or Other ethnicity (including New Zealander). For more detail on classification refer to the Ministry of Health's ethnicity data protocols [13]. The denominator data used to determine disease rates for ethnic groups was based on the proportion of people in each ethnic group from the usually resident 2013 census population applied to the 2014 and 2015 mid-year population estimates. Rates for ethnic groups were age-standardised to the New Zealand Census 2013 population.

This report presents the number of cases and population rates for different ethnic groups. However, caution should be exercised in the interpretation of these numbers, as ethnicity information is not always provided, different ethnic groups have different patterns of health care access, and the numbers may not accurately reflect the true burden of disease in the population.

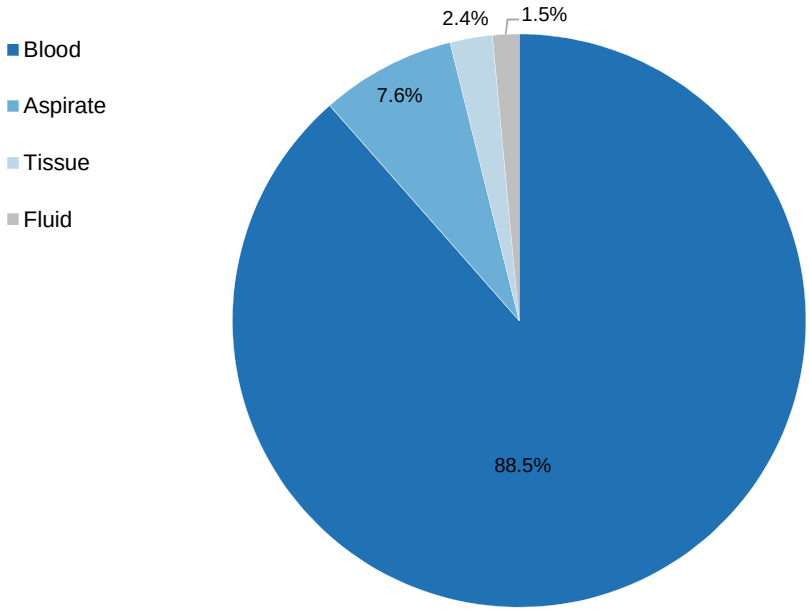
Deprivation index

Socio-economic deprivation is based on the New Zealand index of deprivation 2013 (NZDep2013). The index, measuring relative socioeconomic deprivation, is derived from a weighted combination of nine variables from the 2013 census, each reflecting a different aspect of material and social deprivation [10]. The deprivation score is calculated for each geographical mesh block in New Zealand. Deprivation scores are grouped into deciles 1 to 10, where 1 represents the least deprived areas and 10 the most deprived areas. The denominator data used to determine disease rates for NZDep2013 categories is based on the proportion of people in each NZDep2013 category from the usually resident 2013 census population applied to the 2014 and 2015 mid-year population estimates.

RESULTS

Applying our case definition, a total of 672 invasive GAS infections were identified in 2014 and 2015. Of these, 670 infections (99.7%) were based on isolation of GAS from a sterile site: 593 (88.5%) from blood, 51 (7.6%) from bone and joint, 16 (2.4%) from tissue with necrotising fasciitis in the symptoms field, and one from foetal tissue, 10 (1.5%) from cerebrospinal, pleural or peritoneal fluids (Figure 1). For the remaining two cases where the site was not specified or was unclear, both had a diagnosis code of A40.0 (sepsis due to streptococcus, group A) and one also had a diagnosis of O85 (puerperal sepsis).

Figure 1. Proportion of invasive GAS isolates by site, 2014–2015

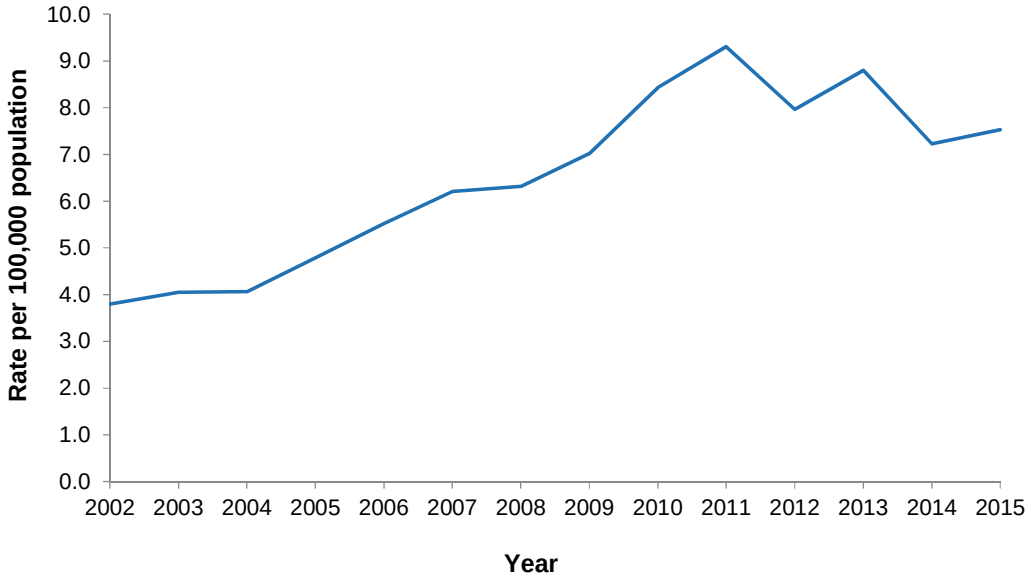


TREND IN DISEASE INCIDENCE BY YEAR

There were 326 invasive GAS isolates referred to ESR in 2014 and 346 in 2015, giving a rate of 7.2 and 7.5 per 100,000 population, respectively.

Between 2002 and 2011 there was an increasing trend in the rate of invasive GAS infections, from 3.8 per 100,000 population to 9.3 per 100,000. Since 2011 the rate has been variable but overall there has been a decreasing trend to 7.5 per 100,000 in 2015 (Figure 2, Table 2).

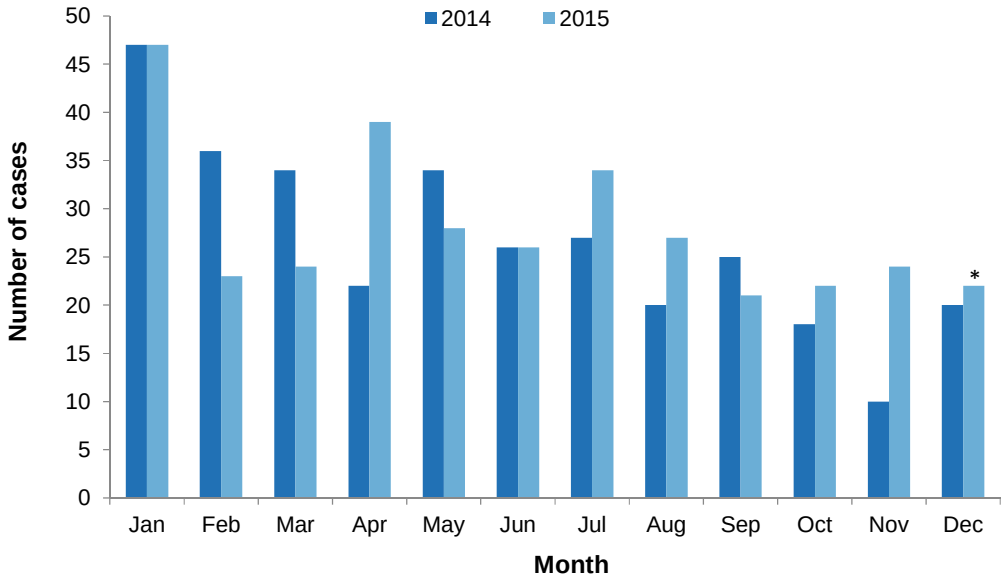
Figure 2. Invasive GAS infection rates by year, 2002–2015



DISEASE INCIDENCE BY MONTH

Figure 3 shows the monthly distribution of invasive GAS cases based on the date the specimen was collected. Cases where the specimen was collected in December 2013 but received at ESR in January 2014 (n=16) have been excluded. Invasive GAS infection peaked in summer with the highest number of invasive GAS cases occurring in January for both 2014 and 2015 (47 cases in each year).

Figure 3. Number of cases of invasive GAS infection by month specimen collected, 2014 and 2015



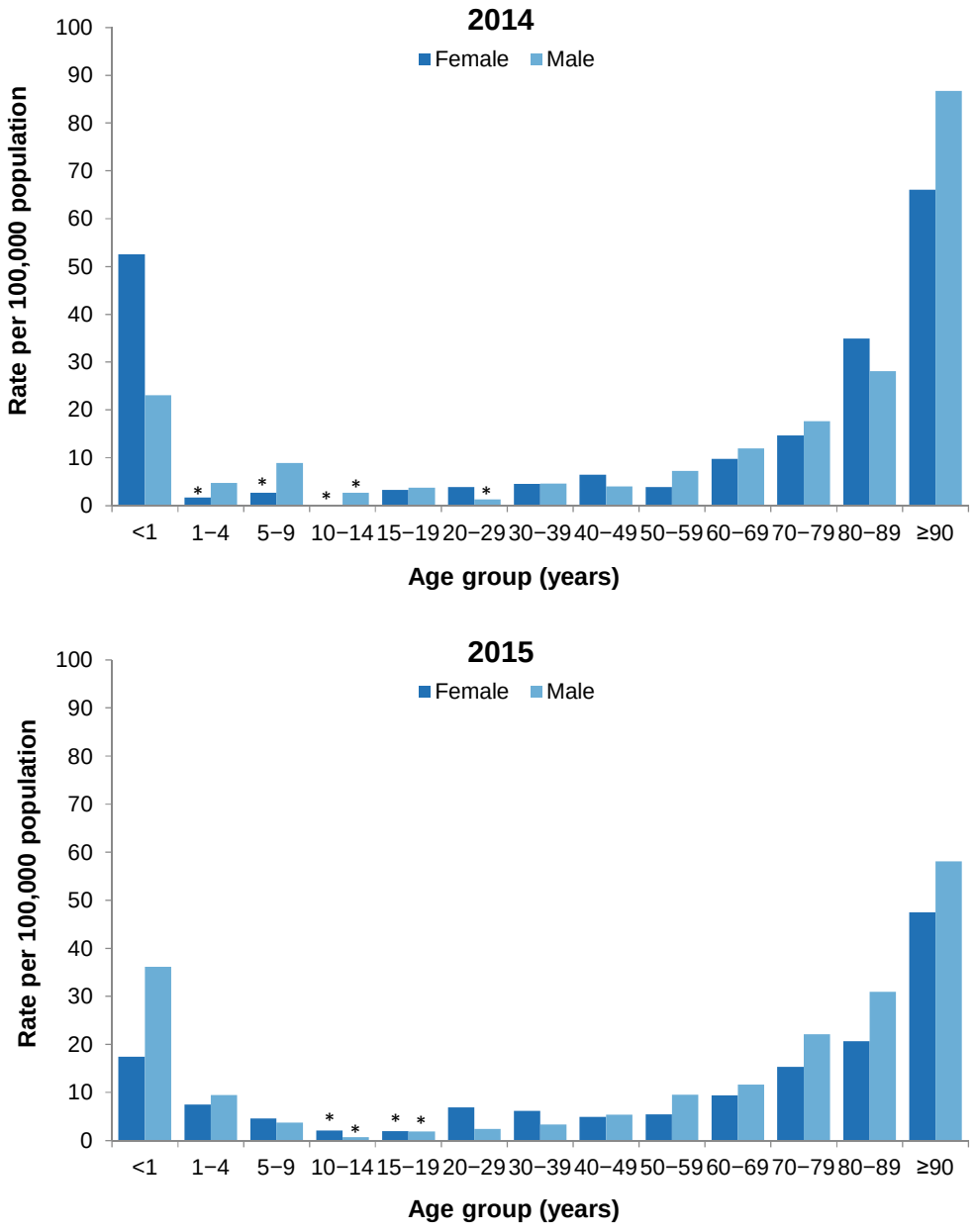
* Data incomplete as specimens collected in December 2015 and received at ESR in January 2016 are not included.

DISEASE INCIDENCE BY AGE AND SEX

The distribution of cases of invasive GAS infection by age group and sex is presented in Figure 4 and Table 3. Age and sex were available for all but one case.

The age distribution in both years followed a U-shaped curve with highest rates in the youngest and oldest age groups (Figure 4). The rate for infants aged <1 year was 37.4 per 100,000 in 2014 and 27.1 per 100,000 in 2015, and for adults aged ≥90 years the rates were 72.5 and 50.8 per 100,000 respectively (Table 3). The rates for all other age groups ranged from 1.4 to 32.0 per 100,000. In general, males had slightly higher rates than females in both years with the main exception being the <1 year age group in 2014.

Figure 4. Invasive GAS infection rates by age group and sex, 2014 and 2015



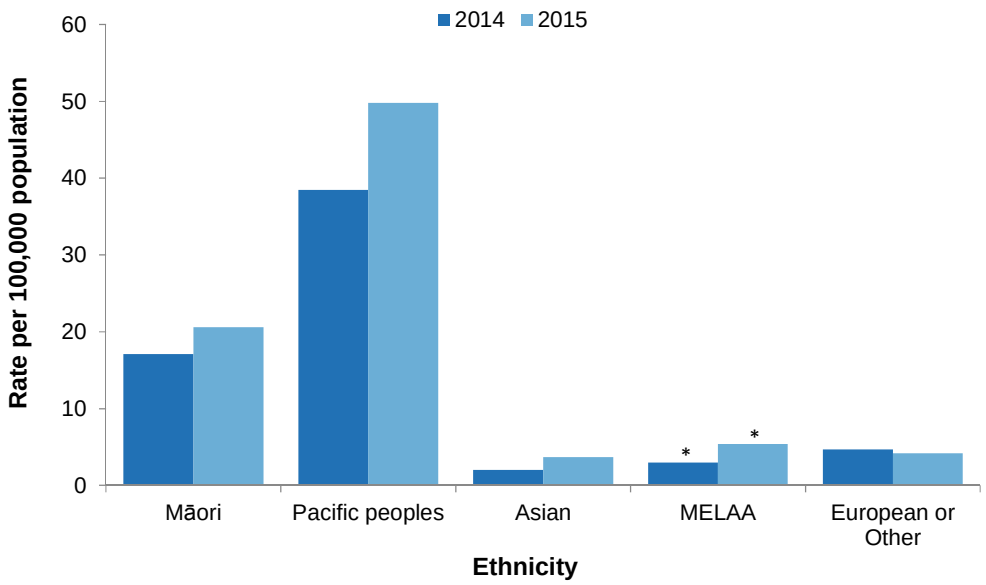
* Rate based on fewer than five cases.

DISEASE INCIDENCE BY ETHNICITY

Ethnicity was known for 98.8% (664/672) of cases of invasive GAS infection in 2014 and 2015 (98.2% in 2014 and 99.4% in 2015). The age-standardised rates by ethnic group are shown in Figure 5 and Table 4.

Pacific peoples had the highest age-standardised rate of invasive GAS infection followed by Māori in both 2014 and 2015. For Pacific peoples, the 2014 rate was over eight times the European or Other rate (38.5 compared with 4.7 per 100,000) and the 2015 rate was over 11 times the European or Other rate (49.8 compared with 4.2 per 100,000). For Māori the 2014 rate (17.1 per 100,000) was over three times the European or Other rate and the 2015 rate (20.6 per 100,000) was almost five times the European or Other rate (Table 4).

Figure 5. Age-standardised rates of invasive GAS infection by ethnicity, 2014 and 2015

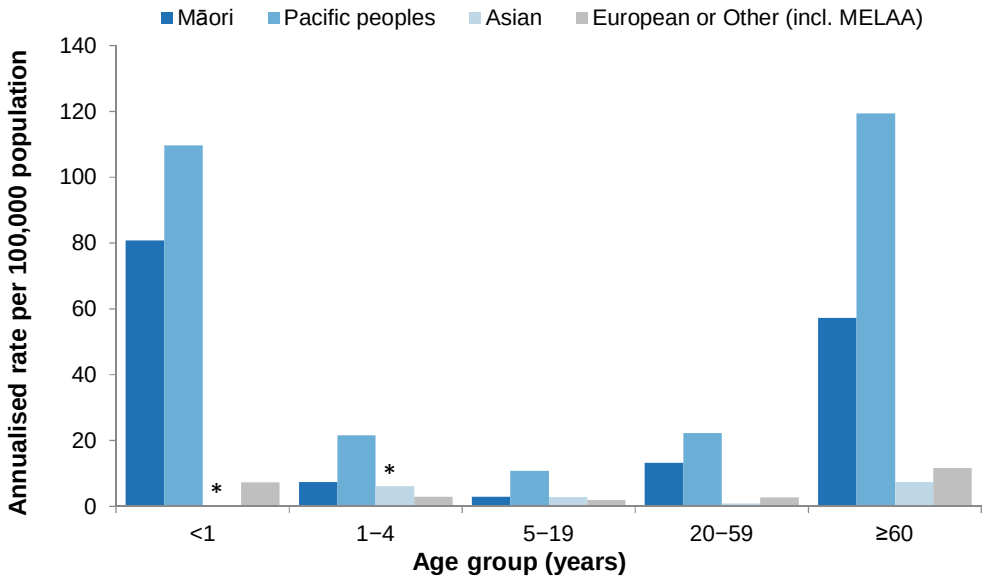


Age-standardised to the New Zealand Census 2013 population.
* Rate based on fewer than five cases.
MELAA: Middle Eastern/Latin American/African.

DISEASE INCIDENCE BY AGE AND ETHNICITY

Pacific peoples aged over 60 years and <1 year had the highest annual rates of invasive GAS infection for 2014 and 2015 combined (119.3 per 100,000 and 109.7 per 100,000 respectively). Māori aged <1 year and over 60 years also had high rates (80.8 per 100,000 and 57.2 per 100,000 respectively). All other age groups had ethnic-specific rates below 23 per 100,000 (Figure 6).

Figure 6. Annualised rate of invasive GAS infection by age group and ethnicity, 2014–2015



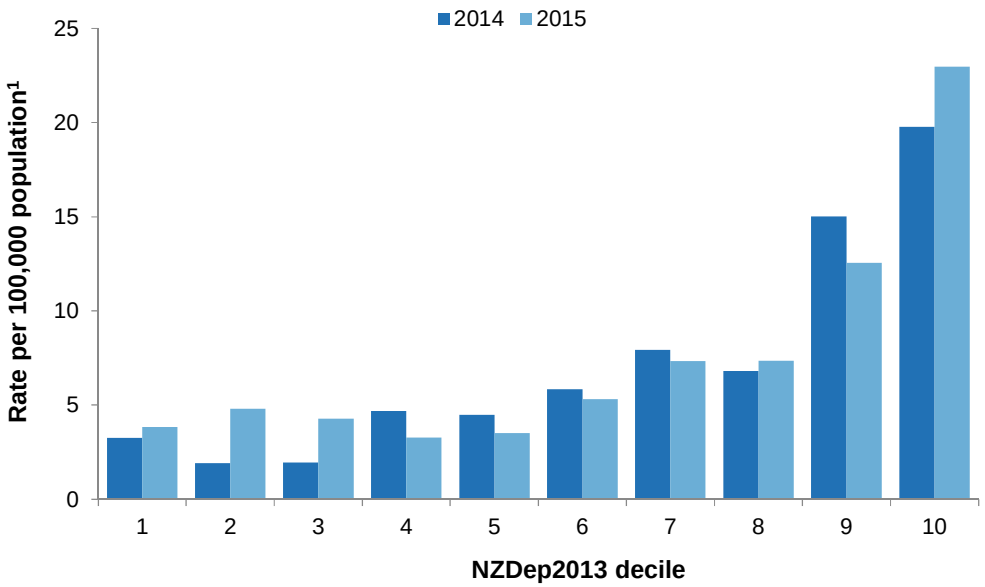
* Rate based on fewer than five cases.

DISEASE INCIDENCE BY DEPRIVATION

The NZDep2013 decile could be assigned for 98.4% (661/672) of cases of invasive GAS infection in 2014 and 2015 (97.9% in 2014 and 98.8% in 2015). The distribution by NZDep2013 is shown in Figure 7 and Table 5.

There is a trend of an increasing rate of invasive GAS infections with increasing deprivation. Nearly half of the invasive GAS infection cases in both 2014 and 2015 (48.3% and 46.8%, respectively) were from the most deprived areas (NZDep13 deciles 9 and 10). In both 2014 and 2015 the highest rates of invasive GAS were in decile 10 (19.8 and 23.0 per 100,000, respectively) and decile 9 (15.0 and 12.5 per 100,000, respectively) (Table 5). The rates in these most deprived deciles were three to six times the rate in decile 1.

Figure 7. Invasive GAS infection rates by deprivation, 2014 and 2015

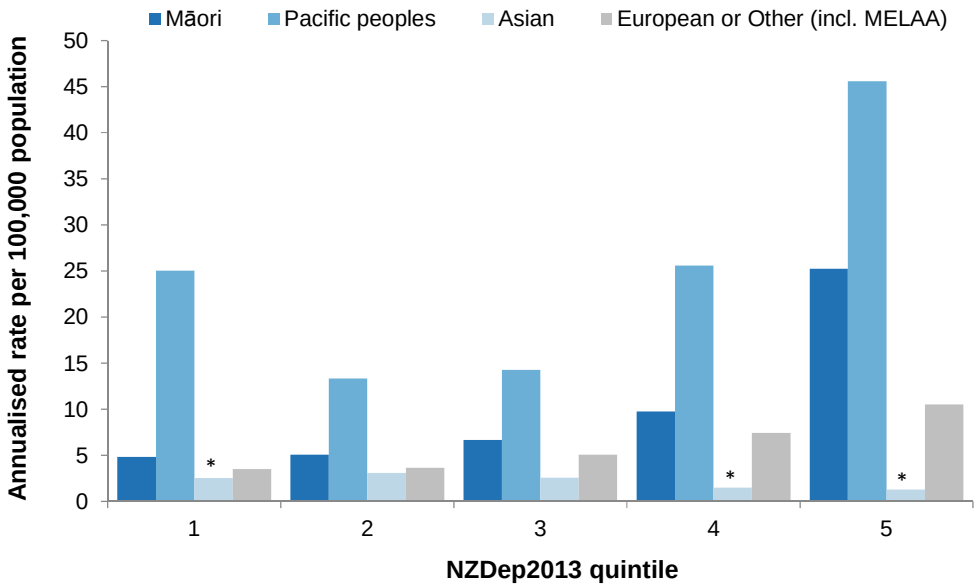


[1] The denominator data used to determine disease rate for deprivation categories is based on the proportion of people in each NZDep2013 category from the usually resident 2013 census population data applied to the 2014 and 2015 mid-year population estimates.

DISEASE INCIDENCE BY ETHNICITY AND DEPRIVATION

Rates of invasive GAS infection increase with increasing deprivation for Māori and European or Other ethnic groups, while for Pacific peoples there is a high rate in NZDep2013 quintile 1 and then an increasing trend in quintiles 2–5 (Figure 8).

Figure 8. Annualised rate of invasive GAS infection by ethnicity and deprivation, 2014–2015



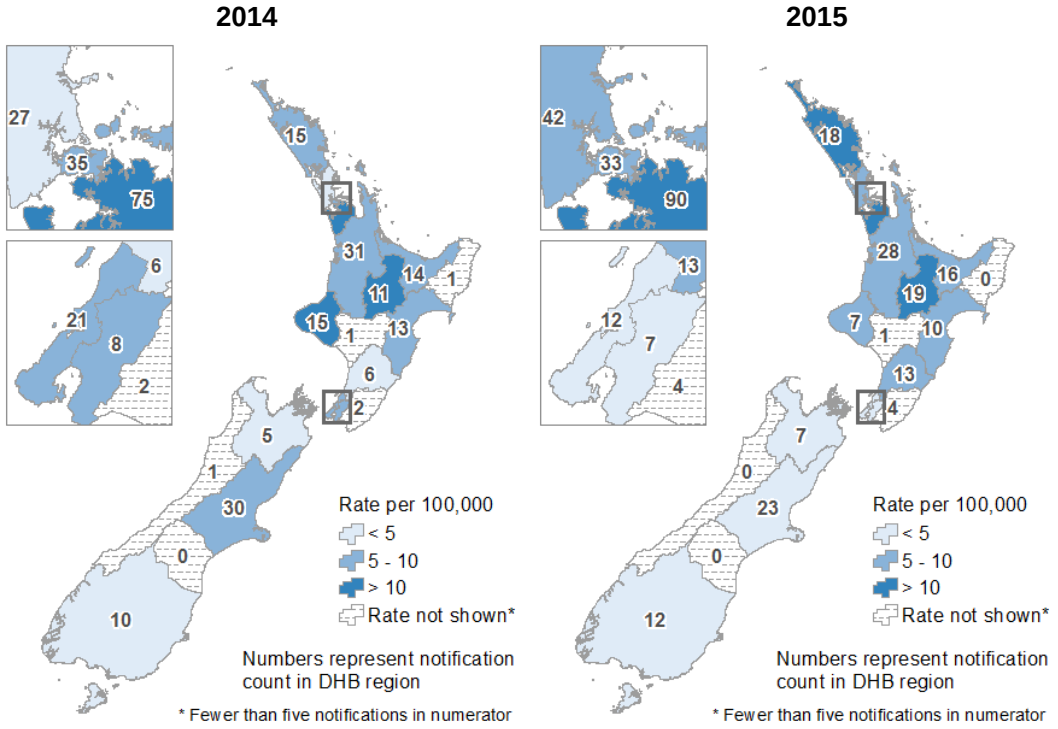
* Rate based on fewer than five cases.

DISEASE INCIDENCE BY DISTRICT HEALTH BOARD

District health board (DHB) was known for 98.7% (663/672) of cases of invasive GAS infection (98.5% in 2014 and 98.8% in 2015). The distribution of cases by DHB is presented in Figure 9 and Table 6.

The highest rate in 2014 was for Counties Manukau (14.7 per 100,000) followed by Taranaki (13.0 per 100,000) and Lakes (10.6 per 100,000) DHBs. In 2015 the highest rates were for Lakes (18.1 per 100,000), Counties Manukau (17.3 per 100,000) and Northland (10.7 per 100,000) DHBs (Table 6).

Figure 9. Number of cases and rate per 100,000 population of invasive GAS infection by DHB, 2014 and 2015

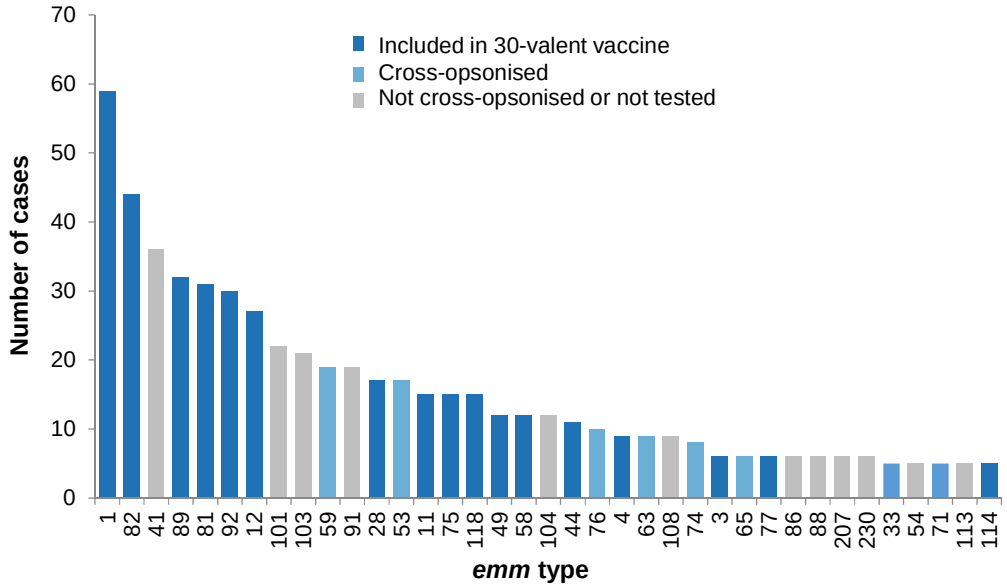


Maps do not include five cases in 2014 and four cases in 2015 where the DHB was unknown.

EMM TYPE DISTRIBUTION

The five most common *emm* types for invasive GAS infections in 2014 and 2015 were *emm*1, 82, 41, 89 and 81, together accounting for 30.1% (202/672) of all isolates (Figure 10 and Table 7). Six of the top seven are *emm* types are in the proposed 30-valent vaccine currently undergoing a phase I trial. In 2014 and 2015, 54.0% (363/672) of cases had *emm* types that are in the proposed 30-valent vaccine (Figure 10) with the theoretical protection potentially rising to 70.2% (472/672) with cross-opsonisation (cross-protection) [5, 6].

Figure 10. Number of cases of invasive GAS infection by *emm* type, 2014–2015



emm types with fewer than five cases in total for 2014 and 2015 are not included.

30-DAY MORTALITY

There were 56 deaths within 30 days among cases of invasive GAS infection in 2014 and 2015 (35 and 21 respectively). The 30-day case mortality rate was 8.3% (56/672). The median age of cases at death was 77.5 years. The mortality rate among adults increased with age, with the highest 30-day mortality occurring in cases aged ≥90 years (36.4%) (Figure 11, Table 8).

Figure 11. Case mortality rate for invasive GAS infection by age group, 2014–2015

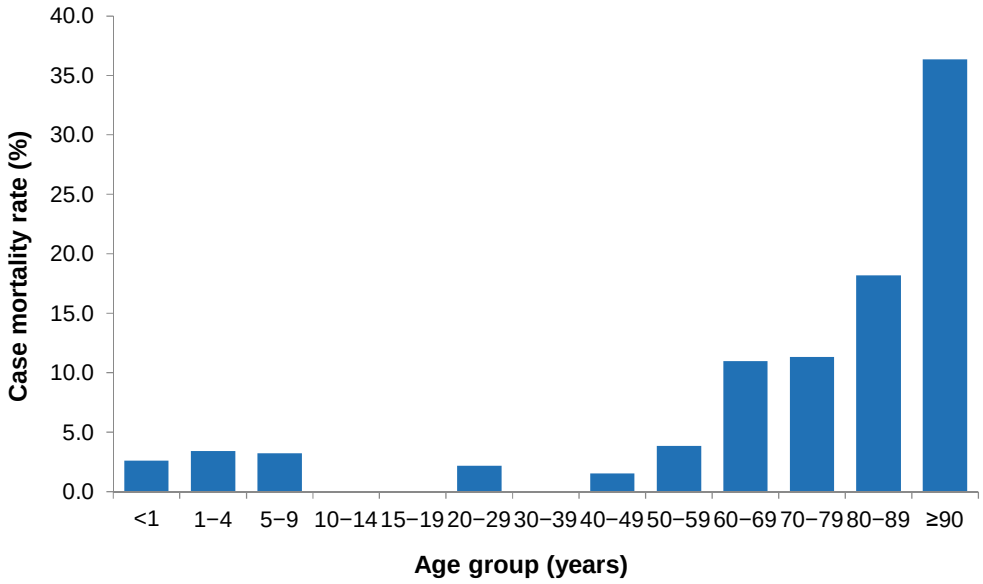


Table 1 shows the *emm* types associated with 30-day mortality in 2014–2015. The *emm* type associated with the highest number of deaths was *emm*1 (7 deaths), which was also the most common *emm* type identified. However, *emm*92 (16.7%) had the highest case mortality rate among the top five *emm* types associated with the highest number of deaths. Four of the top five *emm* types associated with the highest number of deaths are covered by the proposed 30-valent vaccine (*emm*1, *emm*12, *emm*81 and *emm*92).

Table 1. Number of deaths for invasive GAS infection by *emm* type, 2014 and 2015

emm type	Number of deaths[1]			Total cases	30-day case mortality rate (%)
	2014	2015	Total		
1	5	2	7	59	11.9
92	3	2	5	30	16.7
81	4	0	4	31	12.9
101	2	1	3	22	13.6
12	1	2	3	27	11.1
114	2	0	2	5	40.0
118	2	0	2	15	13.3
41	0	2	2	36	5.6
42	1	1	2	4	50.0
58	2	0	2	12	16.7
59	0	2	2	19	10.5
76	0	2	2	10	20.0
82	1	1	2	44	4.5
89	1	1	2	32	6.3
91	2	0	2	19	10.5
2	0	1	1	4	25.0
104	1	0	1	12	8.3
108	0	1	1	9	11.1
112	1	0	1	1	100.0
113	1	0	1	5	20.0
222	1	0	1	1	100.0
230	1	0	1	6	16.7
233	0	1	1	4	25.0
4	1	0	1	9	11.1
28	0	1	1	17	5.9
44	1	0	1	11	9.1
49	0	1	1	12	8.3
63	1	0	1	9	11.1
65	1	0	1	6	16.7
Other[2]	0	0	0	201	0.0
Grand Total	**35**	**21**	**56**	**672**	**8.3**

[1] Deaths within 30 days of laboratory sample collection or date received at ESR if unknown.

[2] Remaining *emm* types with no 30-day mortality associated.

DISCUSSION

This report describes the epidemiology of invasive GAS disease in New Zealand and the distribution of invasive GAS isolates genotyped at ESR in 2014 and 2015. We identified an incidence rate for invasive GAS infections of 7.2 per 100,000 population for 2014 and 7.5 per 100,000 for 2015. An increase in the incidence of invasive GAS infections in New Zealand was reported from 3.9 per 100,000 population in 2002 to 9.3 in 2011, dropping to 7.9 per 100,000 in 2012 [2]. The 2014 and 2015 rates were slightly lower than that reported in 2012 but remain about twice the rates reported in other high-income countries of 2–4 per 100,000 population[3, 14, 15].

Similar to other high-income countries, highest rates were seen at the extremes of age in the very young (<1 year) and in older people (≥80 years) [9]. The rate for Pacific peoples was over eight times higher than the rate for European or Other in 2014, increasing to over 11 times higher in 2015. One study from the United States reported invasive GAS was 1.6 times more likely to occur among black persons than among those of other race [4] and other reports have noted ethnic differences in invasive GAS disease, with people of African American, Hispanic, and Native American descent likely to have higher rates than White Americans [16]. High rates were also associated with high socioeconomic deprivation in New Zealand with almost half (48% and 47%) of the cases from the most deprived quintile (NZDep2013 deciles 9 and 10) in 2014 and 2015 respectively. We assessed invasive GAS infections by ethnicity and level of socioeconomic deprivation. There was a pattern of increasing invasive GAS infection rates with increasing levels of deprivation for Māori, less marked for European or Other ethnicities. Williamson *et al*. noted the socioeconomic disparity and commented that although reasons for the disparity were unknown, lower socioeconomic status is linked to a high prevalence of other known risk factors for invasive GAS disease such as obesity, diabetes mellitus and cardiovascular disease [2].

Interestingly, invasive GAS infection in New Zealand does not follow the more typical winter/spring seasonal pattern, with more cases in 2014 and 2015 occurring in January, our summer, and no increase over winter/spring months (Figure 3). This pattern is consistent with data from 2002–2012 that also had a slight peak in January [D Williamson, personal communication]. This is in contrast to high-income countries in the northern hemisphere which show an increase in winter and spring months [3, 17, 18].

We report a 30-day mortality rate of 8.3% for 2014–2015 which was slightly lower than that reported by Williamson *et al*. for invasive GAS infections from 2002 to 2012 of 10.1% [2] but falls within the case mortality rate range reported from other high income countries of 8% to 16% [1, 4, 16]. The 30-day mortality in 2014–2015 follows a similar pattern to other reports of increasing mortality with increasing age, with almost one in four cases with invasive GAS infection dying in the ≥80 years age group.

Molecular *emm* typing is important to understand the epidemiology of invasive and non-invasive GAS infections and to assess the potential benefit of a vaccine in relation to disease incidence in New Zealand. International data on *emm* typing has informed the development of GAS vaccines. The leading candidate GAS vaccine is a 30-valent vaccine consisting of the following *emm* types: 1, 2, 3, 4, 5, 6, 11, 12, 14, 18, 19, 22, 24, 28, 29, 44, 49, 58, 73, 75, 77, 78, 81, 82, 83, 87, 89, 92, 114 and 118 (StreptAnova^{TM}) [6]. This vaccine has completed phase I trial and results are pending. The New Zealand Australian Coalition to Advance New Vaccines Against Group A *Streptococcus* (CANVAS) is actively working towards progressing a GAS vaccine [19]. However, it is important to note that the experimental GAS vaccine is largely based on data from the United States and may not address the specific *emm* types circulating in New Zealand.

Williamson *et al.* noted in their study of invasive GAS isolates in New Zealand from 2002 to 2012 that 59% of invasive GAS isolates would be covered by the proposed 30-valent vaccine. With cross-opsonisation (cross-protection of non-vaccine *emm* types in laboratory assays), the theoretical coverage increased to 67% [2]. In 2014 and 2015, the most common *emm* type for invasive GAS cases was *emm*1 (8.8%, 59 cases) followed by *emm*82 (6.5%, 44 cases) and *emm*41 (5.4%, 36 cases). Of these three types, *emm*1 and 82 are in the experimental 30-valent GAS vaccine. For 2002–2012 the most common *emm* types for invasive GAS infection in New Zealand were *emm*1, *emm*49, *emm*81, *emm*75 and *emm*89 which are all included in the 30-valent vaccine [2]. As noted by Williamson *et al.* there is diversity in circulating *emm* types by year which makes decisions about which *emm* types to include in a potential vaccine a challenge [2].

As seen in Figure 10, four of the top five *emm* types circulating in New Zealand in 2014 and 2015 would be covered by the leading candidate 30-valent GAS vaccine. Up to 54.0% of cases in 2014 and 2015 may be prevented by the proposed 30-valent vaccine - depending on vaccine efficacy and coverage. Theoretical protection from the vaccine could potentially increase to about 70% of cases being prevented if cross-opsonisation is taken into account [5, 6]. However, it is important to note that further studies are needed to characterise the potential effect of *in vitro* cross-opsonisation on vaccine efficacy in a clinical setting.

The highest numbers of cases and highest risks of mortality were among older people (≥60 years). This will need to be taken into consideration should a GAS vaccine become available, to ensure the right age groups are targeted for vaccination.

The focus on primary prevention of rheumatic fever through active case finding and management of GAS pharyngitis in recent years includes strategies to increase awareness of rheumatic fever and how to prevent it, reduce household crowding and improve access to effective treatment for streptococcal sore throat infections. These strategies may also have had an impact on rates of invasive GAS infection.

Our analysis has several limitations, in particular it uses laboratory data from passive surveillance so is likely to underestimate the true incidence of invasive GAS infection in New Zealand. In addition, a limited amount of information is available from laboratory records and we have no information on clinical symptoms, risk factors or comorbidities to inform our analyses. Continued surveillance of invasive GAS infection and laboratory molecular typing of isolates will be important to monitor trends in New Zealand.

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APPENDIX

Table 2. Number of cases and rate per 100,000 population of invasive GAS infection by year, 2002–2015

Year	Cases	Rate[1]
2002	150	3.8
2003	163	4.0
2004	166	4.1
2005	198	4.8
2006	231	5.5
2007	262	6.2
2008	269	6.3
2009	302	7.0
2010	367	8.4
2011	408	9.3
2012	351	8.0
2013	391	8.8
2014	326	7.2
2015	346	7.5

[1] Rate per 100,000 population.

Table 3. Number of cases and rate per 100,000 population of invasive GAS infection by sex and age group, 2014 and 2015

Age group (years)	2014						2015					
	Female		Male		Total		Female		Male		Total	
	Cases	Rate[1]	Cases	Rate[1]	Cases	Rate[1]	Cases	Rate[1]	Cases	Rate[1]	Cases	Rate[1]
<1	15	52.5	7	23.1	22	37.4	5	17.4	11	36.1	16	27.1
1–4	2	-	6	4.7	8	3.2	9	7.5	12	9.5	21	8.5
5–9	4	-	14	8.9	18	5.9	7	4.6	6	3.7	13	4.1
10–14	0	-	4	-	4	-	3	-	1	-	4	-
15–19	5	3.3	6	3.7	11	3.5	3	-	3	-	6	1.9
20–29	12	3.9	4	-	16	2.6	22	6.9	8	2.4	30	4.6
30–39	13	4.5	12	4.6	25	4.5	18	6.2	9	3.3	27	4.8
40–49	21	6.4	12	4.0	33	5.3	16	4.9	16	5.4	32	5.1
50–59	12	3.9	21	7.3	33	5.5	17	5.4	28	9.5	45	7.4
60–69	23	9.7	27	12.0	50	10.8	23	9.4	27	11.6	50	10.5
70–79	21	14.6	23	17.7	44	16.1	23	15.4	30	22.1	53	18.6
80–89	27	34.9	16	28.1	43	32.0	16	20.6	18	30.9	34	25.0
≥90	12	66.1	7	86.7	19	72.5	9	47.4	5	58.1	14	50.8
Unknown	0	-	0	-	0	-	0	-	1	-	1	-
Total	**167**	**7.3**	**159**	**7.2**	**326**	**7.2**	**171**	**7.3**	**175**	**7.8**	**346**	**7.5**

[1] Rate per 100,000 population. Where there were fewer than five cases in any category, a rate has not been calculated.

Table 4. Number of cases of invasive GAS infection by ethnicity and age group, 2014 and 2015

Age group (years)	2014							2015						
	Māori	Pacific peoples	Asian	MELAA[1]	European or Other	Unknown	Total	Māori	Pacific peoples	Asian	MELAA[1]	European or Other	Unknown	Total
<1	12	7	0	0	3	0	22	7	7	0	0	2	0	16
1–4	2	3	0	0	3	0	8	5	8	3	0	5	0	21
5–9	4	3	1	1	8	1	18	2	4	4	0	3	0	13
10–14	1	2	0	0	1	0	4	1	1	0	0	2	0	4
15–19	2	3	0	0	6	0	11	0	6	0	0	0	0	6
20–29	7	6	1	0	2	0	16	11	8	0	0	11	0	30
30–39	5	4	0	1	15	0	25	6	6	1	0	14	0	27
40–49	8	12	1	0	12	0	33	15	10	1	0	6	0	32
50–59	9	10	0	0	12	2	33	14	17	1	0	13	0	45
60–69	19	13	0	0	17	1	50	15	12	2	1	19	1	50
70–79	9	7	2	0	24	2	44	11	13	0	0	28	1	53
80–89	3	6	1	0	33	0	43	6	6	2	0	20	0	34
≥90	0	0	0	0	19	0	19	0	0	0	0	14	0	14
Unknown	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Total	**81**	**76**	**6**	**2**	**155**	**6**	**326**	**94**	**98**	**14**	**1**	**137**	**2**	**346**
Crude rate[2]	**12.0**	**27.3**	**1.2**	**-**	**5.2**	**-**	**7.2**	**13.7**	**34.7**	**2.7**	**-**	**4.5**	**-**	**7.5**
Age-standardised rate[3]	**17.1**	**38.5**	**2.0**	**-**	**4.7**	**-**	**7.2**	**20.6**	**49.8**	**3.7**	**-**	**4.2**	**-**	**7.5**

[1] Middle Eastern/Latin American/African.

[2] Rate per 100,000 population for all ages. Where there were fewer than five cases in any category, a rate has not been calculated. The denominator data used to determine disease rates for ethnic groups is based on the proportion of people in each ethnic group from the usually resident 2013 census population applied to the 2014 and 2015 mid-year population estimates.

[3] Age-standardised rate per 100,000 population, standardised to the New Zealand census 2013 population.

Table 5. Number of cases and rate per 100,000 population of invasive GAS infection by deprivation, 2014 and 2015

NZDep2013 category[1]	2014		2015	
	Cases	Rate[2]	Cases	Rate[2]
1	15	3.3	18	3.8
2	9	1.9	23	4.8
3	9	2.0	20	4.3
4	21	4.7	15	3.3
5	20	4.5	16	3.5
6	26	5.9	24	5.3
7	35	7.9	33	7.3
8	30	6.8	33	7.3
9	67	15.0	57	12.5
10	87	19.8	103	23.0
Unknown	7	-	4	-
Total	**326**	**7.3[2]**	**346**	**7.6[2]**

[1] New Zealand index of deprivation (1 = least deprived and 10 = most deprived).

[2] Rate per 100,000 population. Denominator data is based on the proportion of people in each NZDep2013 category from the usually resident 2013 census population applied to the 2014 and 2015 mid-year population estimates. Total rates vary slightly from other tables due to the different population used for rate calculations.

Table 6. Number of cases and rate per 100,000 population of invasive GAS infection by DHB, 2014 and 2015

District health board	2014		2015	
	Cases	Rate[2]	Cases	Rate[2]
Northland	15	9.0	18	10.7
Waitemata	27	4.8	42	7.3
Auckland	35	7.4	33	6.7
Counties Manukau	75	14.7	90	17.3
Waikato	31	8.1	28	7.2
Lakes	11	10.6	19	18.1
Bay of Plenty	14	6.4	16	7.2
Tairawhiti	1	-	0	-
Taranaki	15	13.0	7	6.0
Hawke's Bay	13	8.2	10	6.2
Whanganui	1	-	1	-
MidCentral	6	3.5	13	7.6
Wairarapa	2	-	4	-
Hutt Valley	8	5.6	7	4.9
Capital & Coast	21	7.1	12	4.0
Nelson Marlborough	5	3.5	7	4.8
West Coast	1	-	0	-
Canterbury	30	5.8	23	4.4
South Canterbury	0	-	0	-
Southern	10	3.2	12	3.8
Unknown	5	-	4	-
Total	**326**	**7.2**	**346**	**7.5**

[1] Rate per 100,000 population. Where there were fewer than five cases in any category, a rate has not been calculated.

Table 7. Number of cases of invasive GAS infection by *emm* type, 2014 and 2015

emm cluster	30-valent theoretical coverage	*emm* type	2014	2015	Total	Percentage (%)[1]
A-C3	vaccine antigen	1	33	26	59	8.8
E3	vaccine antigen	82	23	21	44	6.5
D4	not determined	41	17	19	36	5.4
E4	vaccine antigen	89	9	23	32	4.8
E6	vaccine antigen	81	15	16	31	4.6
E2	vaccine antigen	92	13	17	30	4.5
A-C4	vaccine antigen	12	11	16	27	4.0
D4	not determined	101	6	16	22	3.3
E3	not determined	103	11	10	21	3.1
E6	cross-opsonised	59	7	12	19	2.8
D4	not determined	91	10	9	19	2.8
E4	vaccine antigen	28	10	7	17	2.5
D4	cross-opsonised	53	6	11	17	2.5
E6	vaccine antigen	11	10	5	15	2.2
E6	vaccine antigen	75	6	9	15	2.2
E3	vaccine antigen	118	14	1	15	2.2
E3	vaccine antigen	49	4	8	12	1.8
E3	vaccine antigen	58	7	5	12	1.8
E2	not determined	104	9	3	12	1.8
E3	vaccine antigen	44	5	6	11	1.6
E2	cross-opsonised	76	3	7	10	1.5
E1	vaccine antigen	4	3	6	9	1.3
E6	cross-opsonised	63	6	3	9	1.3
D4	not determined	108	3	6	9	1.3
M74	cross-opsonised	74	3	5	8	1.2
A-C5	vaccine antigen	3	4	2	6	0.9
E6	cross-opsonised	65	5	1	6	0.9
E4	vaccine antigen	77	4	2	6	0.9
D4	not determined	86	4	2	6	0.9
E4	not determined	88	4	2	6	0.9
D1	not determined	207	2	4	6	0.9
D4	not determined	230	4	2	6	0.9
D4	cross-opsonised	33	2	3	5	0.7
D1	not cross-opsonised	54	1	4	5	0.7
D2	cross-opsonised	71	3	2	5	0.7
E3	not determined	113	5	0	5	0.7
E4	vaccine antigen	114	4	1	5	0.7
		Other[2]	40	54	94	14.0
		Total	**326**	**346**	**672**	**100.0**

[1] Percentage of total cases.

[2] Includes the remaining *emm* types with fewer than five cases in total for 2014 and 2015.

Source: [5, 6]

Table 8. Number of deaths for invasive GAS infection by age group, 2014 and 2015

Age group (years)	Number of deaths[1]			Total cases	30-day case mortality rate (%)
	2014	2015	Total		
<1	1	0	1	38	2.6
1–4	1	0	1	29	3.4
5–9	1	0	1	31	3.2
10–14	0	0	0	8	0.0
15–19	0	0	0	17	0.0
20–29	0	1	1	46	2.2
30–39	0	0	0	52	0.0
40–49	0	1	1	65	1.5
50–59	2	1	3	78	3.8
60–69	9	2	11	100	11.0
70–79	5	6	11	97	11.3
80–89	9	5	14	77	18.2
≥90	7	5	12	33	36.4
Total	**35**	**21**	**56**	**672**	**8.3**

[1] Deaths within 30 days of laboratory sample collection or date received at ESR if unknown

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