Science for Communities

INVASIVE PNEUMOCOCCAL DISEASE IN NEW ZEALAND, 2016

PREPARED FOR: Ministry of Health as part of the contract for scientific services

CLIENT REPORT No: FW190193

PREPARED BY: Liza Lopez, Helen Heffernan, Charlotte Gilkison, Jill Sherwood

Health Intelligence Team, Health and Environment Group
Institute of Environmental Science and Research Limited

PUBLISHED: July 2019

This report is available at www.surv.esr.cri.nz

Published: 5 July 2019

Suggested citation:

Institute of Environmental Science and Research Ltd (ESR).
Invasive pneumococcal disease in New Zealand, 2016. Porirua: ESR; 2019.

Client Report: FW19019

ACKNOWLEDGEMENTS

This report was prepared by Liza Lopez, Helen Heffernan, Charlotte Gilkison, Jill Sherwood and Julie Morgan.

Thanks to the following people for their contributions to this report:

- Public Health Unit staff for provision of notification data for their regions.
- Diagnostic microbiology laboratories throughout New Zealand who participate in the national laboratory-based surveillance of invasive pneumococcal disease by referring isolates to ESR.
- Julie Morgan and Heather Davies from the ESR Invasive Pathogens Laboratory for serotyping data.
- Staff in the ESR Antibiotic Reference Laboratory for antimicrobial susceptibility data.
- Rebekah Roos (former ESR staff) for preparing the data and completing part of the analyses.
- Giles Graham from the ESR Health Intelligence Team for peer checking.
- Emma Best, University of Auckland and the Ministry of Health for peer review.

DISCLAIMER

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
CLSI	Clinical and Laboratory Standards Institute
CSF	Cerebrospinal fluid
DHB	District Health Board
ESR	Institute of Environmental Science and Research Ltd
EUCAST	European Committee on Antimicrobial Susceptibility Testing
I	Intermediate resistance
IPD	Invasive pneumococcal disease
MELAA	Middle Eastern/Latin American/African
MDR	Multidrug resistant
MIC	Minimum inhibitory concentration
NHI	National Health Index
NIR	National Immunisation Register
NT	Non-typable
NZDep13	2013 New Zealand Index of Deprivation
PCR	Polymerase chain reaction
PCV	Pneumococcal conjugate vaccine
PCV7	7-valent pneumococcal conjugate vaccine
PCV10	10-valent pneumococcal conjugate vaccine
PCV13	13-valent pneumococcal conjugate vaccine
PHU	Public Health Unit
PPV23	23-valent pneumococcal conjugate vaccine
R	Resistant
S	Susceptible

SUMMARY

In June 2008, a 7-valent pneumococcal conjugate vaccine (PCV7), Prevenar® was added to the New Zealand childhood immunisation schedule. In July 2011, this was replaced with the 10-valent conjugate vaccine (PCV10), Synflorix® and in July 2014, Synflorix® was replaced by the 13-valent conjugate vaccine (PCV13), Prevenar13®. In July 2017, Synflorix® will be re-introduced to the childhood immunisation schedule and replace Prevenar13®. Synflorix® has cross-reactivity to serotype 19A, one of the three additional serotypes included in Prevenar13®.

Since 17 October 2008, invasive pneumococcal disease (IPD) has been a notifiable disease in New Zealand. In this report, the data presented for 2009–2016 is based on IPD case notifications supplemented with serotype and antimicrobial susceptibility data from ESR's national laboratory-based surveillance of invasive *Streptococcus pneumoniae* isolates. Data for earlier years is solely from ESR's laboratory-based surveillance. For the laboratory-based surveillance, diagnostic microbiology laboratories are requested to refer all invasive isolates of *S. pneumoniae* to ESR for serotyping and antimicrobial susceptibility testing.

There were 480 cases of IPD notified in 2016, which equates to a rate of 10.2 cases per 100,000 population. An *S. pneumoniae* isolate from an invasive site was received at ESR for serotyping and antimicrobial susceptibility testing for 455 (94.8%) of the notified cases.

In children <5 years of age, the overall rate of IPD (ie, disease due to any serotype) has decreased 71.8% (from 53.5 to 15.1 per 100,000) between the average rate in 2006–2007, and 2016. The rate due to PCV10 serotypes, including cross-reactive 19A[1], has decreased 88.4% (from 47.8 to 5.6 per 100,000 population) between the 2006–2007 average rate and the rate in 2016.

In 2016, rates of IPD for the Pacific peoples and Māori ethnic groups were 5.7 times and 3.8 times higher, respectively, than the rate for the European or Other ethnic group. Twelve (54.5%) of the 22 cases in the <2 years age group were of Māori (8 cases) or Pacific peoples (4 cases) ethnicity.

The all-age rate of pneumococcal meningitis was 0.9 per 100,000.

The IPD case-fatality rate was 4.7%.

The highest all-age rate of IPD was in Tairawhiti District Health Board (DHB) (20.9 per 100,000, 10 cases), followed by Lakes (20.6 per 100,000, 22 cases), Northland (18.7 per 100,000, 32 cases) and South Canterbury (18.6 per 100,000, 11 cases) DHBs. Between 2009 and 2016, rates of IPD have decreased across most DHBs.

Due to the indirect or herd immunity effects of routine infant PCV immunisation, there have also been significant 48.7% and 67.5% reductions in the rates of IPD due to PCV10 serotypes, including cross-reactive 19A, in the 5–64 years and ≥65 years age groups, respectively, between the 2006–2007 average rate and the 2016 rate. Since notification-

[1] PCV10 is licensed as providing protection against serotype 19A disease through serotype 19F eliciting cross-reactive antibodies against serotype 19A.

based surveillance began in 2009, there has also been a decrease in the overall rate of IPD in the 5–64 years age group and the ≥65 years age groups (36.8% and 37.1%).

The most prevalent serotypes in 2016 were 19A (78 cases), 22F (39 cases), 7F (33 cases), 8 (29 cases) and 3 (27 cases). These five types collectively accounted for 45.3% (206/455) of the culture-positive cases typed in 2016. Serotype 19A has been the most common serotype among IPD cases since 2011 with a non-significant increase in the 5–64 years age group and a significant increase in the ≥65 years age group since PCV was first introduced in 2008.[1]

In addition to these increases in 19A disease in the older age groups, there have been two one-off annual increases in the <2 years age group - between 2011 and 2012 and again between 2013 and 2014. In 2016 there were six cases of serotype 19A IPD reported in the <2 years age group, compared with 12 in 2014 and two in 2015.

The rates of IPD due to the PCV10 serotype 7F increased in the 5–64 years and ≥65 years age groups between 2011 and 2013. However, following the introduction of PCV10 in 2011, there were successive decreases in the rates of IPD due to type 7F in both these age groups, between 2014–2016. These decreases are probably an indication that the switch from PCV7 to PCV10 for routine infant immunisation in 2011 is now having an indirect effect on type 7F disease in the older age groups.

After an increase in 2014 in the prevalence of IPD due to the PCV13 serotype 3 in the <65 years age groups, cases decreased again in 2016. In 2016 there were two cases of serotype 3 in the <2 years age group compared with seven in 2014. Whether this decrease in type 3 disease in 2016 is the result of increasing coverage of the <2 years age group with PCV13 following the change to this vaccine in 2014 is uncertain given that literature suggests minimal protection against carriage or disease is provided for serotype 3 by PCV13.

There were 10 apparent vaccine failures in 2016 with all cases having completed the routine childhood immunisation schedule with at least the last dose being a vaccine that covered the serotype responsible for their disease. Eight of these cases were due to serotype 19A, of whom two were reported to have underlying chronic health conditions. The remaining two cases were due to serotype 3.

Based on the European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints, 23.5% of isolates were resistant to penicillin (meningitis breakpoints) and 0.9% were cefotaxime resistant. Since the introduction of PCV there has been little change in the prevalence of antimicrobial resistance among invasive pneumococcal isolates. However, PCV7 types constitute a decreasing proportion of penicillin-resistant isolates and serotype 19A isolates an increasing proportion, as much as 48.6% in 2016.

INTRODUCTION

Since 17 October 2008, invasive pneumococcal disease (IPD) has been a notifiable disease in New Zealand. Prior to this date, national surveillance of IPD was solely laboratory-based, with diagnostic laboratories voluntarily referring invasive isolates of *Streptococcus pneumoniae* to the Institute of Environmental Science and Research Ltd (ESR) for serotyping and antimicrobial susceptibility testing.

On 1 June 2008, pneumococcal conjugate vaccine (PCV) was added to the New Zealand childhood immunisation schedule, with a catch-up programme for all children born on or after 1 January 2008. Initially the 7-valent conjugate vaccine (PCV7), Prevenar®, was used. In July 2011, Prevenar® was replaced on the schedule with the 10-valent conjugate vaccine (PCV10), Synflorix®. In July 2014, Synflorix® was replaced by the 13-valent conjugate vaccine (PCV13), Prevenar13® [2]. With both the change to PCV10 in 2011 and the change to PCV13 in 2014, there was no catch-up programme for children fully or partially vaccinated with a lower-valency PCV. Any child who was part-way through their 4-dose PCV course completed the course with the higher-valency vaccine. Although both these schedule changes occurred mid-year, the actual use of the new vaccines did not begin until some months later as supplies of the lower-valency vaccines were depleted. There will be a further schedule change in July 2017, when Synflorix® will be re-introduced to the childhood immunisation schedule and replace Prevenar13®. Synflorix® has cross-reactivity to serotype 19A shown on post-marketing surveillance one of the three additional serotypes included in Prevenar13® leading to it becoming registered for cross-protection against 19A in April, 2016.

This series of annual reports on the epidemiology of IPD in New Zealand commenced in 2008. The 2008 annual report was based on data available from ESR's national laboratory-based surveillance of IPD.[3] Subsequent annual reports have been based on IPD notifications, supplemented with serotype and antimicrobial susceptibility data from ESR's laboratory-based surveillance.[1, 4-9]

Prior to these annual reports, information from ESR's laboratory-based surveillance of IPD was published periodically.[10-14] In addition, between 2002 and 2007, annual reports on the antimicrobial susceptibility of invasive pneumococcal isolates were published on ESR's Public Health Surveillance website at http://www.surv.esr.cri.nz/antimicrobial/streptococcus_pneumoniae.php.

This report presents information on cases of IPD that were notified in 2016, as well as trend data for recent surveillance years.

METHODS

SURVEILLANCE METHODS

In this report, data for 2009 to 2016 is based on IPD case notifications from a secure web-based portal onto a computerised database (EpiSurv), supplemented with serotype and antimicrobial susceptibility data from ESR's national laboratory-based surveillance of invasive *S. pneumoniae* isolates. Data for earlier years is solely from ESR's laboratory-based surveillance of IPD.

Since 17 October 2008, IPD has been notifiable to the local medical officer of health under the Health Act 1956. A case of IPD requires laboratory confirmation by at least one of the following [15]:

- isolation of *S. pneumoniae* from blood, cerebrospinal fluid (CSF) or another normally sterile site (eg, joint fluid, pleural fluid)
- detection of *S. pneumoniae* nucleic acid from blood, CSF or another normally sterile site
- a positive newer generation *S. pneumoniae* antigen test on CSF or pleural fluid [2].

Notification data is entered at each public health unit (PHU) via EpiSurv. The data is collated and analysed on behalf of the Ministry of Health by ESR. The case report form is available in the Appendix.

For the national laboratory-based surveillance of IPD, diagnostic microbiology laboratories in New Zealand are requested to refer to ESR all invasive isolates of *S. pneumoniae* (ie, isolates from CSF, blood or another normally sterile site). At ESR, all invasive isolates are serotyped and tested for susceptibility to a range of antibiotics. Further details are provided in the section entitled *Laboratory methods*.

The notification data in this report is based on the information recorded on EpiSurv as at 3 August 2017. Any changes made to the notification data by PHU staff after this date are not reflected in this report. Serotype and antimicrobial susceptibility data for invasive isolates was matched with the relevant case notification.

The immunisation status of cases age-eligible for PCV (ie, cases born after 1 January 2008) is based on data from the National Immunisation Register (NIR) rather than the immunisation data reported with the case notification in EpiSurv. Further details are provided in the section entitled *Analytical methods*. The immunisation status of asplenic cases is based on the immunisation data reported with the case notification in EpiSurv.

LABORATORY METHODS

Strain typing

S. pneumoniae isolates are serotyped by the capsular antigen reaction (Neufeld test) using the Danish system of nomenclature and sera obtained from the Statens Serum Institut.[16] The full range of factorised antisera is not held by ESR. Consequently, the serotypes of some isolates could not be determined. In this report, isolates not able to be serotyped are described by their serogroup followed by the designation NT (non-typable)

[2] CSF positive antigen test was added to the case definition in 2009 and pleural fluid positive antigen test in 2016.

or as ‘Non-typable’ if unable to be typed by any antisera. Additional factor sera was available from July 2014 for Group 15 and June 2015 for Group 16 and 35.

Antimicrobial susceptibility testing

In 2016 the methods used to test the antimicrobial susceptibility of invasive *S. pneumoniae* isolates at ESR were changed from those of the Clinical and Laboratory Standards Institute (CLSI) to the methods of the European Committee on Antimicrobial Susceptibility Testing (EUCAST).[17, 18] Specifically, penicillin and cefotaxime susceptibilities were determined by Etest (bioMerieux, France), using EUCAST Mueller-Hinton Fastidious agar and incubation for 20–24 hours in 5% CO_2. Chloramphenicol, clindamycin, co-trimoxazole, erythromycin, moxifloxacin, rifampicin, tetracycline and vancomycin susceptibilities were determined by EUCAST disc susceptibility testing methods.[17] Inducible clindamycin resistance was detected by the D-zone test.[17] All minimum inhibitory concentrations (MICs) and zone of inhibition diameters were interpreted according to the 2016 EUCAST clinical breakpoints.[17, 18]

The antimicrobial susceptibility data presented in this report for the years prior to 2016 is based on CLSI methods and breakpoints.[19, 20] EUCAST breakpoints, where they differ from CLSI breakpoints, have not been retrospectively applied to MICs and zone diameters determined by CLSI methods due to differences between the two methods. In this report, when associations between penicillin resistance and patient demographics, geographical distribution or serotypes are made, penicillin resistance as defined by the meningitis breakpoints have been used. The EUCAST and CLSI penicillin meningitis breakpoints are the same (susceptible, MIC ≤0.06 mg/L; resistant, MIC ≥0.12 mg/L). These penicillin breakpoints are also those commonly used for surveillance purposes.

In this report, multidrug resistance (MDR) is defined as resistance to three antibiotics in addition to penicillin. For the purposes of this definition, the meningitis breakpoints for penicillin were used.

ANALYTICAL METHODS

The denominator data used to determine all disease rates, except the rates for ethnic groups and deprivation index, is derived from the 2016 mid-year population estimates published by Statistics New Zealand. All rates are presented as the number of cases per 100,000 population. Note that rates presented in this report for years prior to 2016 may differ slightly from those published in earlier annual reports as the mid-year population estimates are updated each year. 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 2016 mid-year population estimates. The demographic data presented for cases are obtained from the Episurv record. Where ethnicity is reported as unknown in the EpiSurv record (approximately 20% of cases), this information is obtained from the Ministry of Health, through matching to the National Health Index (NHI) database. Any cases that cannot be matched to the NHI database remain of unknown 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).

Socio-economic deprivation is based on the 2013 New Zealand Index of Deprivation (NZDep13). 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. The deprivation score is calculated for each geographical meshblock in New Zealand. Quintiles of NZDep13, ranging from 1 (least deprived) to 5 (most deprived), are presented in this report. Approximately equal numbers of people reside in areas associated with each of the five deprivation levels. The deprivation index analysis was confined to those cases for which the accuracy of index designation was recorded as exact or nearest. Rates presented were calculated using population data derived from the usually resident 2013 census population.

Clinical presentation is determined from the EpiSurv record which is completed through the review of available clinical records. Notifiers are advised to report specific clinical presentations over 'bacteraemia without focus'. More than one clinical presentation may be recorded for some cases of IPD. The clinical presentations are prioritised in the following order: meningitis, empyema, pneumonia, bacteraemia without focus (positive blood culture without a specific clinical site of infection) and 'Other'. In this report, any cases for which *S. pneumoniae* was identified in CSF (by culture, polymerase chain reaction (PCR) or antigen test) and which were not notified as meningitis cases were considered to be cases of pneumococcal meningitis.

More than one method of laboratory confirmation may be recorded for some cases of IPD. The method of laboratory confirmation is prioritised in the following order: culture of *S. pneumoniae* from CSF, culture of *S. pneumoniae* from blood, detection of *S. pneumoniae* DNA in CSF, positive pneumococcal antigen test on CSF, detection of *S. pneumoniae* DNA in blood, culture of *S. pneumoniae* from pleural fluid, culture of *S. pneumoniae* from joint fluid, culture of *S. pneumoniae* from another normally sterile site, detection of *S. pneumoniae* DNA in pleural fluid, positive pneumococcal antigen test of pleural fluid, detection of *S. pneumoniae* DNA in joint fluid and detection of *S. pneumoniae* DNA in other normally sterile site.

IPD notifications from EpiSurv were matched with relevant data in the NIR for cases born after 1 January 2008 only. The NIR data obtained included the dates of vaccination, the type of PCV administered (ie, PCV7, PCV10 or PCV13), and the batch number of the vaccine given. The batch numbers of all PCV issued from the former National Vaccine Store at ESR were obtained and were used to cross-check the NIR data on the type of vaccine administered. Any doses of PCV given within 14 days of disease onset were not counted in the analysis.

Vaccine failure is defined as IPD with a vaccine serotype where disease onset is at least 14 days after completion of either the routine New Zealand Immunisation Schedule, or an age appropriate catch-up schedule. At least the final dose should be with the relevant serotype specific vaccine.[19]

The Fisher's exact test was used to determine the significance of any observed differences. Linear regression was used to calculate the significance and direction of time trends. An associated p-value of <0.05 was used to identify whether a difference or trend was significant.

Data presented for 2009 onwards is based on IPD notifications from EpiSurv and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD. Compared with notifications, laboratory-based surveillance is likely to underestimate the burden of IPD. In some time-series data presentations in the Appendix of this report, due to page-size limitations, the years 2008–2010 have been omitted. These three years represent the year

in which PCV was added to the childhood immunisation schedule and the following two years. However, the earlier years, 2006 and 2007, have been retained to represent the pre-PCV era. Data for 2008–2010 can be obtained from earlier annual reports.[2-7]

VACCINE ABBREVIATIONS

PCV7: 7-valent pneumococcal conjugate vaccine with serotypes 4, 6B, 9V, 14, 18C, 19F and 23F.

PCV10: 10-valent pneumococcal conjugate vaccine with serotypes 1, 4, 5, 6B, 7F, 9V, 14, 18C, 19F and 23F.

PCV13: 13-valent pneumococcal conjugate vaccine with serotypes 1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F and 23F.

PPV23: 23-valent pneumococcal polysaccharide vaccine with serotypes 1, 2, 3, 4, 5, 6B, 7F, 8, 9N, 9V, 10A, 11A, 12F, 14, 15B, 17F, 18C, 19A, 19F, 20, 22F, 23F and 33F.

RESULTS

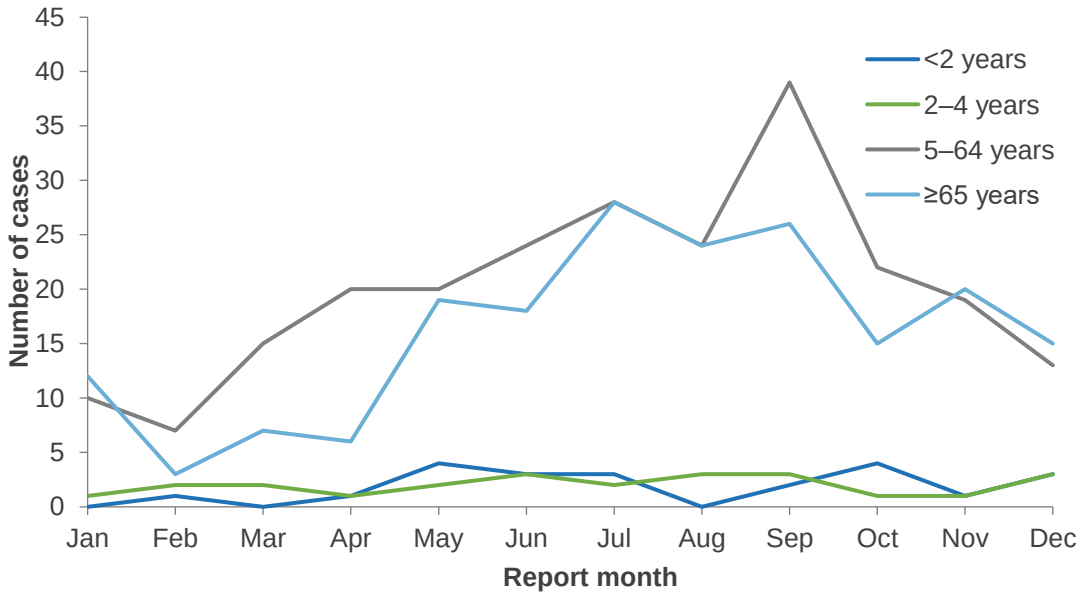
In 2016, 480 cases of IPD were notified. The 2016 notification rate for IPD was 10.2 cases per 100,000 population, similar to the 2015 rate (9.7 per 100,000, 447 cases).

A breakdown of the laboratory criteria upon which the IPD diagnosis was based is available in Table 12 (Appendix). In 2016, 90.0% of cases were confirmed by culture of *S. pneumoniae* from blood. *S. pneumoniae* isolates from an invasive site were received by ESR for serotyping and antimicrobial susceptibility testing from 455 (94.8%) of the 480 cases notified in 2016.

DISEASE INCIDENCE BY SEASON

During 2016 there was the usual marked peak of cases in the winter months among cases aged ≥5 years (Figure 1).

Figure 1. Number of invasive pneumococcal disease cases by age group and month, 2016



DISEASE INCIDENCE BY AGE AND SEX

Age and sex were recorded for all IPD cases in 2016. The distribution of the 2016 cases by age group and sex is presented in Table 1. For aggregated age groups, the rates of IPD were highest for males compared with females except in the <2 year age group. The highest rates were in adults aged ≥65 years and in infants aged <2 years. Rates of IPD showed an increasing trend with age from 15 years onwards.

Table 1. Number of cases and rate per 100,000 population of invasive pneumococcal disease by age group and sex, 2016

Age group (years)	Female		Male		Total		
	Cases	Rate[a]	Cases	Rate[a]	Cases	Rate[a]	%[b]
<1	4	-	5	16.4	9	15.2	1.9
1	8	27.6	5	16.2	13	21.7	2.7
2–4	9	10.0	15	15.8	24	12.9	5.0
5–14	8	2.7	8	2.5	16	2.6	3.3
15–24	10	3.1	15	4.3	25	3.7	5.2
25–34	12	3.7	14	4.4	26	4.1	5.4
35–44	14	4.6	12	4.3	26	4.5	5.4
45–54	23	7.0	37	12.1	60	9.4	12.5
55–64	32	11.2	56	20.9	88	15.9	18.3
65–74	45	21.7	43	21.9	88	21.8	18.3
75–84	34	29.7	28	28.7	62	29.2	12.9
≥85	26	50.3	17	54.3	43	51.8	9.0
Aggregated age groups (years)							
<2[c]	12	20.8	10	16.3	22	18.5	4.6
<5	21	14.2	25	16.0	46	15.1	9.6
5–64	99	5.3	142	7.8	241	6.5	50.2
≥65	105	28.1	88	27.1	193	27.6	40.2
Total	**225**	**9.4**	**255**	**10.6**	**480**	**10.2**	**100.0**

[a] Where there were fewer than five cases, a rate has not been calculated.

[b] Percentage of cases in each age group.

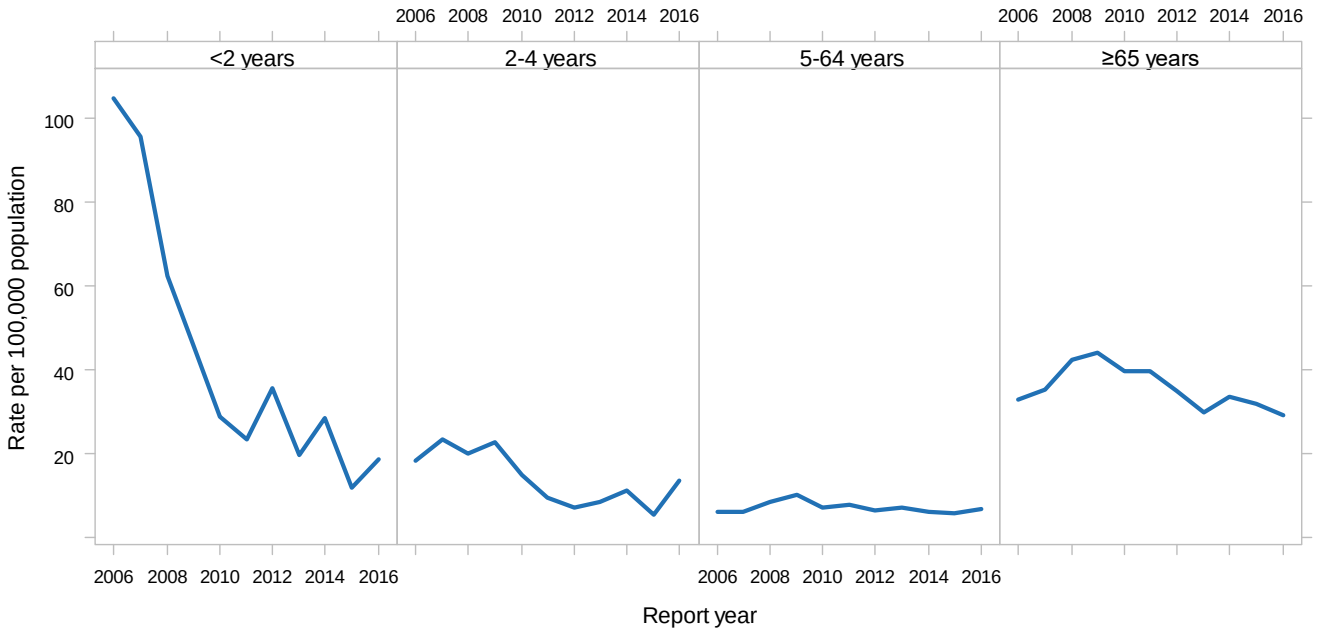
[c] The age in months of the cases <2 years of age is presented in Figure 10 (Appendix).

Between 2006 and 2016, there was a significant 71.8% decrease in the rate of IPD in the <5 years age group (53.5 to 15.1 per 100,000) (Figure 2). The actual reductions in disease rates in this age group may be greater than these figures indicate due to the change in 2009 from laboratory-based surveillance to the more sensitive notification-based surveillance and the introduction of CSF and pleural antigen testing. Although there was a significant increase in the rate of IPD in the 2–4 years age group from 2015 to 2016 (from 5.3 to 12.9 per 100,000, 10 to 24 cases), the 2016 rate was still much lower than the 2006 rate of 18.3 per 100,000 (31 cases). Nine of these cases in 2016 were due to serotype 19A compared with one case in 2015.

The rate in the 5–64 years age group in 2016 was similar to the average rate for 2006–2007, whereas over the same period the rate in the ≥65 years age group decreased from 34.2 to 27.6 per 100,000. However, these results are hard to interpret due to the change during this period from laboratory-based to notification-based surveillance. It is also notable that the rates in both these older age groups decreased significantly over the period of notification-based surveillance of IPD (ie, since 2009), from 10.3 to 6.5 per 100,000 and 44.0 to 27.6 per 100,000 in the 5–64 and ≥65 years age groups, respectively.

A breakdown of cases and rates by age group over the past ten years is available in Table 13 (Appendix).

Figure 2. Rate per 100,000 population of invasive pneumococcal disease by age group and year, 2006–2016



Note: Data presented for 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD.

DISEASE INCIDENCE BY ETHNIC GROUP

Ethnicity was recorded for 466 (97.1%) of the 480 IPD cases in 2016. The age-standardised rates of IPD were highest for the Pacific peoples (40.0 per 100,000, 79 cases) and Māori (26.8 per 100,000, 113 cases) ethnic groups. The rates for these two ethnic groups were, respectively, 5.7 and 3.8 times the rate for the European or Other ethnic group (7.0 per 100,000, 251 cases) (Table 2).

Among the 22 cases aged <2 years, eight cases were of Māori ethnicity, eight cases were European or Other, four cases were Pacific peoples and two cases were of Asian ethnicity.

Between 2009 and 2016, the age-standardised IPD rates decreased significantly in the European or Other (-43.1%) and Māori (-19.3%) ethnic groups (Figure 3). Rates of IPD by ethnic group and age group for the years 2009 to 2016 are presented in Table 14 (Appendix).

Table 2. Number of cases, age-specific and age-standardised rate per 100,000 population of invasive pneumococcal disease by ethnic group and age group, 2016

Age group (years)	Māori		Pacific peoples		Asian		MELAA[a]		European or Other	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
<1	5	32.6	2	-	0	-	0	-	2	-
1	3	-	2	-	2	-	0	-	6	18.0
2–4	7	15.0	4	-	2	-	0	-	10	10.6
5–14	4	-	5	8.8	1	-	0	-	6	1.8
15–24	7	5.4	7	12.4	1	-	0	-	10	2.7
25–34	6	6.3	7	15.9	1	-	0	-	9	2.5
35–44	8	10.1	6	17.5	2	-	0	-	8	2.1
45–54	15	19.8	14	45.8	1	-	1	-	27	5.9
55–64	23	43.9	14	68.6	4	-	0	-	45	10.4
65–74	22	81.0	10	88.6	4	-	1	-	50	14.6
75–84	10	98.4	7	158.4	2	-	0	-	40	21.3
≥85	3	-	1	-	1	-	0	-	38	48.3
Aggregated age groups (years)										
<2	8	25.3	4	-	2	-	0	-	8	12.8
<5	15	19.2	8	27.6	4	-	0	-	18	11.5
5–64	63	10.9	53	21.8	10	2.1	1	-	105	4.5
≥65	35	89.6	18	108.4	7	21.5	1	-	128	21.0
Total cases and crude rate for all ages[b]	**113**	**16.2**	**79**	**27.4**	**21**	**3.9**	**2**	**-**	**251**	**8.1**
Age-standardised rate[c]		**26.8**		**40.0**		**6.5**		**-**		**7.0**

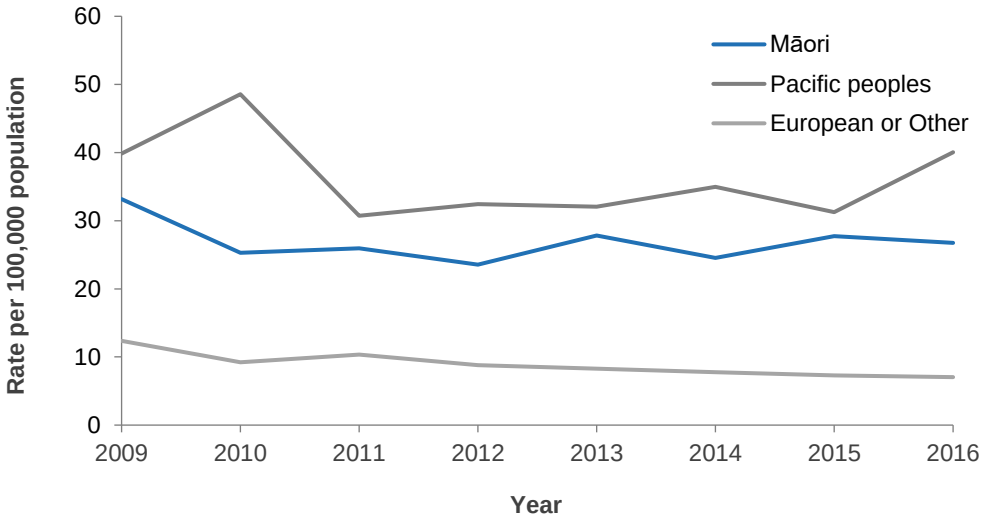
[a] Middle Eastern/Latin American/African.

[b] Ethnicity was recorded for 466 (97.1%) of cases notified in 2016.

[c] The age-standardised rates are direct-standardised to the age distribution of the total New Zealand population.

Note: 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 2016 mid-year population estimates from Statistics New Zealand. Where there were fewer than five cases in any category, a rate has not been calculated.

Figure 3. Age-standardised rate per 100,000 population of invasive pneumococcal disease by ethnic group, 2009–2016



Note: Rates for the Asian and MELAA ethnic groups are not shown due to small numbers.

DISEASE INCIDENCE BY DEPRIVATION

In 2016, 458 (95.4%) of the 480 IPD cases had a residential address recorded that could be assigned an NZDep13 score. In all age groups, at least half the cases resided in NZDep13 quintiles 4 or 5 (Table 3).

The most deprived areas (NZDep13 quintile 5) had the highest rate of IPD (19.6 per 100,000, 172 cases), 3.3 times the rate in the least deprived areas (5.9 per 100,000, 54 cases). Rates of IPD by deprivation index could only be calculated for all ages combined because population data by NZDep13 quintile and age groups was not available.

Between 2009 and 2016, rates of IPD decreased for all NZDep13 quintiles (Table 15, Appendix). The decreases were statistically significant for quintile 2 (-32.1%), quintile 3 (-25.7%), quintile 4 (-37.7%) and quintile 5 (-26.5%).

Table 3. Number and percentage of invasive pneumococcal disease cases by quintiles of the 2013 New Zealand deprivation index and age group, 2016

NZDep13 quintile[a]	<2 years		2–4 years		5–64 years		≥65 years		Total		
	Cases	%[b]	Cases	%[b]	Cases	%[b]	Cases	%[b]	Cases	%[b]	Rate[c]
1	4	19.0	3	12.5	24	10.3	23	12.7	54	11.8	5.9
2	2	9.5	5	20.8	23	9.9	25	13.8	55	12.0	6.2
3	1	4.8	2	8.3	42	18.1	36	19.9	81	17.7	9.2
4	5	23.8	4	16.7	52	22.4	35	19.3	96	21.0	11.1
5	9	42.9	10	41.7	91	39.2	62	34.3	172	37.6	19.6
Total[d]	**21**		**24**		**232**		**181**		**458**		

[a] Quintile of the 2013 New Zealand Deprivation Index (1 = least deprived and 5 = most deprived).

[b] Percentage of cases within the age group in the quintile.

[c] Rate per 100,000 population, based on the 2013 census data from Statistics New Zealand. These rates should not be compared with disease rates used elsewhere in the report which have been calculated using the 2016 mid-year population estimates from Statistics New Zealand.

[d] Accurate New Zealand Deprivation Index (NZDep13) data was available for 458 (95.4%) cases notified in 2016.

DISEASE PRESENTATION, HOSPITALISATIONS AND FATALITIES

In 2016, 474 (98.8%) of the 480 IPD cases had at least one clinical presentation recorded (Table 4). Among infants aged <1 year, meningitis and bacteraemia without focus were the most common presentations (55.6% and 22.2%, respectively). Pneumonia was the most common presentation among cases aged ≥5 years (70.4%).

The rate of pneumococcal meningitis was 0.9 per 100,000 across all age groups (Table 16 in the Appendix).

The five cases of pneumococcal meningitis aged <1 year were in the Māori (3 cases) and European or Other (2 cases) ethnic groups.

Table 4. Clinical presentation of invasive pneumococcal disease cases by age group, 2016

Age group (years)	Meningitis		Empyema		Pneumonia		Bacteraemia without focus		Other		Total[c]
	Cases[a]	%[b]	Cases[a]	%[b]	Cases[a]	%[b]	Cases[a]	%[b]	Cases[a]	%[b]	
<1	5	55.6	1	11.1	1	11.1	2	22.2	0	0.0	9
1	3	25.0	2	16.7	4	33.3	3	25.0	0	0.0	12
2–4	1	4.2	4	16.7	12	50.0	7	29.2	0	0.0	24
5–14	5	31.3	2	12.5	2	12.5	5	31.3	2	12.5	16
15–64	23	10.3	4	1.8	153	68.3	33	14.7	11	4.9	224
≥65	7	3.7	5	2.6	147	77.8	21	11.1	9	4.8	189
Aggregated age groups (years)											
<2	8	38.1	3	14.3	5	23.8	5	23.8	0	0.0	21
<5	9	20.0	7	15.6	17	37.8	12	26.7	0	0.0	45
≥5	35	8.2	11	2.6	302	70.4	59	13.8	22	5.1	429
Total[d]	**44**	**9.3**	**18**	**3.8**	**319**	**67.3**	**71**	**15.0**	**22**	**4.6**	**474**

[a] Number of cases with 'yes' recorded for the clinical presentation. Only one presentation was counted for each case, with presentations prioritised in the following order: meningitis, empyema, pneumonia, bacteraemia without focus and 'Other'. Non-prioritised data, with all presentations recorded for cases that had more than one presentation reported, is available in Table 16 (Appendix). Any cases for which *S. pneumoniae* was identified in CSF were considered to be cases of pneumococcal meningitis.

[b] Percentage of cases within the age group with the clinical presentation.

[c] Number of cases with at least one clinical presentation recorded.

[d] At least one clinical presentation was recorded for 474 (98.8%) of cases notified in 2016.

Information on whether the patient survived or died was recorded for 466 (97.1%) of the IPD cases. IPD was recorded as the primary cause of death for 22 cases, giving a case-fatality rate of 4.7% among the cases for whom this information was reported. There was one death due to IPD reported in the <5 years age group in 2016, compared to none in 2015, one death in 2014 and 2013, four deaths in 2012, no deaths in 2011 and 2010, and one death in 2009. The case-fatality rates for each age group are presented in Table 17 (Appendix). The European or Other ethnic group had the highest case-fatality rate (15/243 cases, 6.2%), followed by Pacific peoples (3/77 cases, 3.9%) and Māori (4/111 cases, 3.6%).

Among the 476 (99.2%) IPD cases for whom hospitalisation status was recorded, 451 (94.7%) cases were hospitalised.

IMMUNISATION STATUS

Immunisation records were identified in the NIR for 53 of the 55 IPD cases in 2016 who were age-eligible for PCV (ie, cases born after 1 January 2008 and aged ≥6 weeks). The two cases who could not be matched to an NIR record were excluded from the subsequent analyses in this section. According to EpiSurv records, one of these cases was aged <2 years and was unimmunised at the time of illness. The immunisation status of the other case, aged 2–4 years, was recorded as unknown.

Forty-six of the 53 cases with an NIR record were reported as having at least two doses of PCV before the onset of their disease (Table 5). The serotype causing IPD was known for 39 of these 46 cases. Among these 39 cases, there were no cases due to PCV7 serotypes, 13 cases due to serotype 19A (covered by PCV10[3] and PCV13), four cases due to serotype 3 (covered by PCV13), and 22 cases due to non-PCV13 serotypes.

Detailed information on the immunisation status for cases age-eligible for PCV and with a known serotype is in the footnotes for Table 5. Eight of the cases due to serotype 19A occurred in children who had completed the routine childhood immunisation schedule with each dose being either PCV10 or PCV13. Of these eight cases, two were reported to have chronic health conditions. Two of the cases due to serotype 3 had completed the childhood schedule with two doses of PCV10 followed by two doses of PCV13.

Table 5. Immunisation status of the 2016 invasive pneumococcal disease cases who were age-eligible for PCV and have an NIR record

Number of doses received[a]	Cases due to PCV7 serotypes: 4, 6B, 9V, 14, 18C, 19F or 23F[b]		Cases due to additional PCV10 serotypes: 1, 5, 7F or cross-reactive 19A[b c]		Cases due to additional PCV13 serotypes: 3 or 6A[b c]		Cases due to non-PCV13 serotypes[b]		Total[b,d]	
	No	%	No	%	No	%	No	%	No	%
0	0	-	3[e]	18.8	0	-	2[f]	7.7	5	9.4
1	0	-	0	-	0	-	1	3.8	2	3.8
2	0	-	0	-	0	-	2	7.7	2	3.8
3	0	-	3[g]	18.8	0	-	7	26.9	11	22.6
4	0	-	10[h]	62.5	4[i]	100	14	53.8	33	60.4
Total	**0**		**16**		**4**		**26**		**53**	

[a] Number of doses received prior to 14 days before onset of IPD. Onset of IPD was determined using the earliest episode date available from onset of illness date, hospitalised date or date reported to the public health unit.

[b] Only IPD cases eligible for PCV as part of the childhood immunisation schedule (ie, cases born after 1 January 2008 and aged ≥6 weeks) are presented.

[c] PCV10 provides protection against 19A disease as serotype 19F elicits cross-reactive antibodies against serotype 19A

[d] The total number of cases includes seven cases where serotype information was not available.

[e] One case due to serotype 7F and two cases due to 19A.

[f] Includes one case who received one dose of PCV13 within 14 days prior to onset of illness.

[g] All cases due to serotype 19A and had received three doses of PCV13.

[h] All cases due to serotype 19A: one had received four doses of PCV13, two had received three doses of PCV13 and one dose of PCV10, one had received three doses of PCV10 and one dose of PCV13, four had received four doses of PCV10, two had received four doses of PCV7.

[i] All cases due to serotype 3: One had received four doses of PCV7, one had received four doses of PCV10, and two had received two doses of PCV10 and two doses of PCV13.

[3] PCV10 is licensed as providing protection against serotype 19A disease through serotype 19F eliciting cross-reactive antibodies against serotype 19A.

Six cases of IPD in 2016 were asplenic. Two of these cases were recorded in EpiSurv as having been immunised with pneumococcal vaccine: a male in the 35–44 years age group with serotype 23B disease (while this case had been vaccinated four years prior to illness with an unknown vaccine type, this serotype is not covered by any pneumococcal vaccines) and a female in the 55–64 years age group with serotype 33F disease (while this serotype is covered by 23PPV, the case was recorded as being vaccinated after the onset of illness). One further case, aged 5–10 years, was able to be matched to the NIR. This case had received four doses of PCV7 only. This case had serotype 22F disease (covered by 23PPV, recommended pre- and post-splenectomy for all ages). The immunisation status of the three other cases was not recorded in EpiSurv (these cases were serotype 10A, 15A and 23B, of which only 10A is covered in any of the vaccines, 23PPV).

Further details of the 11 cases of serotype 19A (covered by PCV10) in the <5 years age group in 2016 are presented in Table 6.

Table 6. Pneumococcal conjugate vaccination history of the serotype 19A invasive pneumococcal disease cases in <5 years age group, 2016

Number of doses received	Case number	Age group	Number of PCV7 doses	Number of PCV10 doses	Number of PCV13 doses
3	1	5–14 months	0	0	3
	2	5–14 months	0	0	3
	3	15–23 months	0	0	3
4	4	15–23 months	0	1	3
	5	15–23 months	0	0	4
	6	2–4 years	0	4	0
	7	2–4 years	0	4	0
	8	2–4 years	0	4	0
	9	2–4 years	0	4	0
	10	2–4 years	0	3	1
	11	2–4 years	0	1	3

There were three cases due to serotype 3 in the <5 years age group (covered by PCV13 not PCV10). Two cases had received two doses of PCV10 and two doses of PCV13, and one had received four doses of PCV10.

RISK FACTORS

The risk factors reported among IPD cases in 2016 are presented in Table 7. The most common risk factor among all cases was chronic illness (57.7%). Risk factors for cases in the <2 years, <5 years and ≥5 years age groups are presented in Table 18, Table 19 and Table 20 (Appendix), respectively. Smoking in the household and attendance at childcare were the most common risk factors recorded for the <2 years age group, although information on these risk factors was only recorded for 32% and 23% of cases, respectively. Chronic illness was the most commonly recorded risk factor for the ≥5 years age group.

Table 7. Exposure to risk factors associated with invasive pneumococcal disease for cases, 2016

Risk factor	Cases[a]	Total reported[b]	%[c]
Chronic illness[d]	255	442	57.7
Premature (<37 weeks gestation)[e]	1	8	12.5
Current smoker[f]	85	362	23.5
Immunocompromised[g]	96	438	21.9
Chronic lung disease or cystic fibrosis	58	437	13.3
Smoking in the household[h]	8	13	61.5
Attends childcare[h]	2	7	28.6
Resident in long-term or other chronic-care facility[i]	25	435	5.7
Cochlear implants	0	410	0.0
Congenital or chromosomal abnormality	5	418	1.2
Anatomical or functional asplenia	6	422	1.4

[a] Number of cases with 'yes' recorded for each risk factor. Some cases reported exposure to more than one risk factor.
[b] Number of cases for which information was recorded for each risk factor.
[c] Percentage of cases with the risk factor for which the information was supplied.
[d] Includes CSF leak, intracranial shunts, diabetes, cardiac disease, pulmonary disease, chronic liver disease, renal impairment and alcohol-related disease.
[e] Cases aged <1 year only.
[f] Cases aged ≥15 years only.
[g] Includes HIV/AIDS, lymphoma, organ transplant, multiple myeloma, nephrotic syndrome, chronic drug therapy, dysgammaglobulinaemia and sickle cell anaemia.
[h] Cases aged <5 years only.
[i] Among cases in the ≥75 years age group, 19.6% (19 cases out of 97 for whom the information was supplied) were residents in a long-term or other chronic-care facility.

DISEASE INCIDENCE BY DISTRICT HEALTH BOARD

The highest rate of IPD was in Tairawhiti DHB (20.9 per 100,000, 10 cases), followed by Lakes (20.6 per 100,000, 22 cases), Northland (18.7 per 100,000, 32 cases) and South Canterbury (18.6 per 100,000, 11 cases) DHBs (Table 8 and Figure 4). Across the regions, rates ranged from 7.1 in the Central region to 12.6 per 100,000 in the Northern region (Table 8).

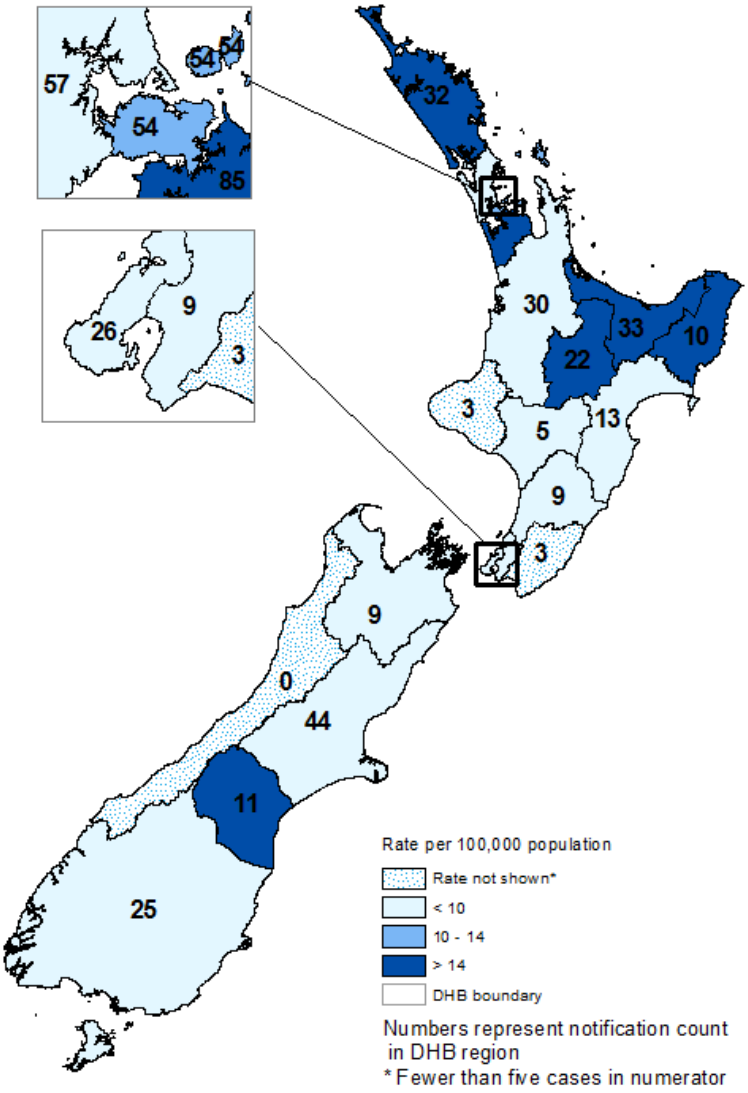
Between 2009 and 2016, rates of IPD have decreased for most DHBs (Table 21 in the Appendix). These decreases were statistically significant in Waikato, Bay of Plenty, Hawke's Bay, Hutt Valley, Nelson Marlborough and Southern DHBs.

Table 8. Number of cases of invasive pneumococcal disease by age group and rate per 100,000 population for each District Health Board, 2016

District Health Board	Cases by age group (years)					Rate[a] (all ages)
	<2	<5	5–64	≥65	All ages	
Northland	1	3	16	13	32	18.7
Waitemata	5	10	26	21	57	9.6
Auckland	4	7	28	19	54	10.6
Counties Manukau	1	6	53	26	85	15.9
Northern region	**11**	**26**	**123**	**79**	**228**	**12.6**
Waikato	0	3	17	10	30	7.5
Lakes	1	3	11	8	22	20.6
Bay of Plenty	3	4	20	9	33	14.6
Tairawhiti	2	2	2	6	10	20.9
Taranaki	0	0	3	0	3	-
Midland region	**6**	**12**	**53**	**33**	**98**	**10.9**
Hawke's Bay	1	1	3	9	13	8.0
Whanganui	0	0	2	3	5	7.9
MidCentral	0	0	3	6	9	5.2
Hutt Valley	0	1	3	5	9	6.2
Capital & Coast	1	1	13	12	26	8.5
Wairarapa	1	1	1	1	3	-
Nelson Marlborough	1	1	3	5	9	6.1
Central region	**4**	**5**	**28**	**41**	**74**	**7.1**
West Coast	0	0	0	0	0	-
Canterbury	0	1	21	22	44	8.2
South Canterbury	0	1	5	5	11	18.6
Southern	1	1	11	13	25	7.8
Southern region	**1**	**3**	**37**	**40**	**80**	**8.4**
Total	**22**	**46**	**241**	**193**	**480**	**10.2**

[a] Where there were fewer than five cases, a rate has not been calculated.

Figure 4. Geographic distribution of invasive pneumococcal disease cases, 2016



SEROTYPE DISTRIBUTION

Table 9 shows, by age group, the number and proportion of the 455 isolates from culture-positive IPD cases referred to ESR in 2016 caused by each of the serotypes included in PCV7, PCV10 and PCV13, and any other serotypes that accounted for five or more cases. Table 22 (Appendix) presents the rates per 100,000 of IPD caused by these same serotypes. Serotype 19A is listed as being an additional serotype under PCV10 as Medsafe accepted in 2016 that PCV10 provides cover as it is cross-reactive to serotype 19A.[20]

In the <2 years age group, nine cases (47.4%) of IPD were due to a PCV13 (the childhood schedule vaccine in 2016) serotype (Table 9). Six cases were serotype 19A, two cases were serotype 3 and one case was serotype 7F. See the Immunisation status section for details of their immunisation.

The proportion of IPD due to PCV13 types was higher in the <5 years age groups compared to the older age groups (Table 9). Among the ≥65 years age group, 69.2% of cases were due to 23PPV serotypes.

A full list of the serotypes of all isolates from culture-positive IPD cases in 2016 is available in Table 22 (Appendix).

Table 9. Number and percentage of invasive pneumococcal disease cases by serotype, serotypes covered by PCV7, PCV10 and PCV13, and age group, 2016

Serotype	<2 years		2–4 years		<5 years[a]		5–64 years		≥65 years[b]		Total	
	Cases	%[c]	Cases	%[c]	Cases	%[c]	Cases	%[c]	Cases	%[c]	Cases	%[c]
4	0	-	1	4.8	1	2.5	15	6.4	5	2.7	21	4.6
6B	0	-	0	-	0	-	1	0.4	0	-	1	0.2
9V	0	-	0	-	0	-	0	-	2	1.1	2	0.4
14	0	-	0	-	0	-	5	2.1	2	1.1	7	1.5
18C	0	-	0	-	0	-	1	0.4	1	0.5	2	0.4
19F	0	-	0	-	0	-	5	2.1	7	3.8	12	2.6
23F	0	-	0	-	0	-	0	-	2	1.1	2	0.4
PCV7	**0**	**-**	**1**	**4.8**	**1**	**2.5**	**27**	**11.6**	**19**	**10.4**	**47**	**10.3**
1	0	-	0	-	0	-	0	-	1	0.5	1	0.2
5	0	-	0	-	0	-	2	0.9	0	-	2	0.4
7F	1	5.3	0	-	1	2.5	26	11.2	6	3.3	33	7.3
19A[d]	6	31.6	9	42.9	15	37.5	32	13.7	31	17.0	78	17.1
PCV10[d]	**7**	**36.8**	**10**	**47.6**	**17**	**42.5**	**87**	**37.3**	**57**	**31.3**	**161**	**35.4**
3	2[e]	10.5	2	9.5	4	10.0	13	5.6	10	5.5	27	5.9
6A	0	-	0	-	0	-	0	-	1	0.5	1	0.2
PCV13	**9**	**47.4**	**12**	**57.1**	**21**	**52.5**	**100**	**42.9**	**68**	**37.4**	**189**	**41.5**
6C	0	-	1	4.8	1	2.5	7	3.0	11	6.0	19	4.2
8	0	-	0	-	0	-	25	10.7	4	2.2	29	6.4
9N	2	10.5	0	-	2	5.0	4	1.7	8	4.4	14	3.1
10A	0	-	0	-	0	-	4	1.7	5	2.7	9	2.0
11A	0	-	0	-	0	-	4	1.7	4	2.2	8	1.8
12F	0	-	0	-	0	-	5	2.1	1	0.5	6	1.3
15A	0	-	1	4.8	1	2.5	6	2.6	7	3.8	14	3.1
15B	2	10.5	1	4.8	3	7.5	2	0.9	2	1.1	7	1.5
16F	0	-	0	-	0	-	7	3.0	4	2.2	11	2.4
17F	0	-	0	-	0	-	3	1.3	6	3.3	9	2.0
22F	1	5.3	2	9.5	3	7.5	16	6.9	20	11.0	39	8.6
23A	0	-	0	-	0	-	4	1.7	5	2.7	9	2.0
23B	0	-	0	-	0	-	9	3.9	9	4.9	18	4.0
31	0	-	0	-	0	-	4	1.7	3	1.6	7	1.5
33F	3	15.8	1	4.8	4	10.0	11	4.7	8	4.4	23	5.1
35B	0	-	1	4.8	1	2.5	5	2.1	3	1.6	9	2.0
38	0	-	1	4.8	1	2.5	1	0.4	4	2.2	6	1.3
Other[f]	2	10.5	1	4.8	3	7.5	16	6.9	10	5.5	29	6.4
Non-PCV[g]	**10**	**52.6**	**9**	**42.9**	**19**	**47.5**	**133**	**57.1**	**114**	**62.6**	**266**	**58.5**
Total[h]	**19**		**21**		**40**		**233**		**182**		**455**	

[a] Aggregated age group.

[b] Among the cases in the ≥65 years age group, 69.2% were due to PPV23 serotypes. Vaccination with PPV23 is recommended for people in this age group.

[c] Percentage of cases within the age group with the serotype.

[d] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[e] Includes one case aged 24 days.

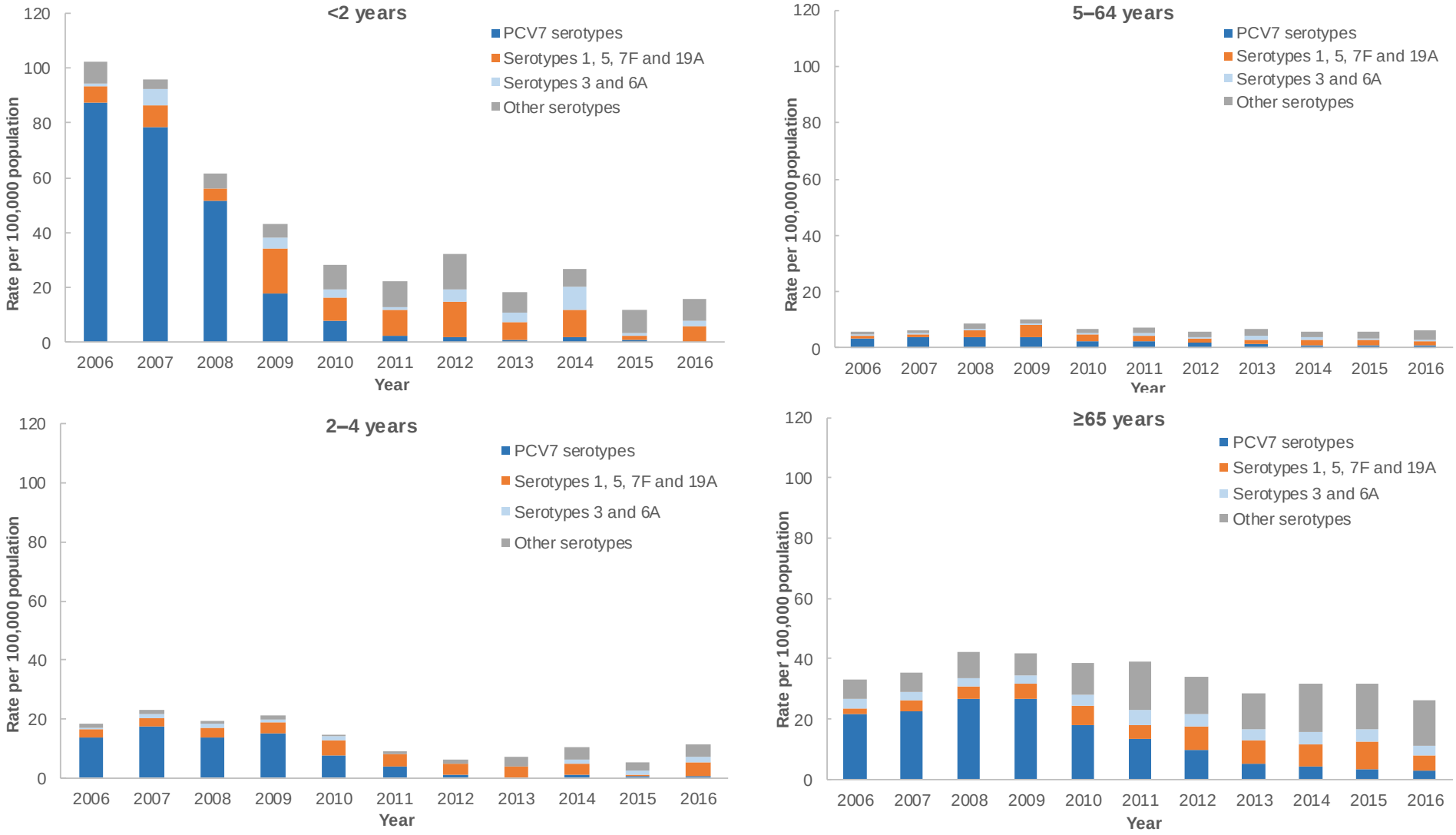
[f] Includes non-PCV serotypes with less than five cases in 2016 and non-typeable serotypes.

[g] The specific non-PCV serotypes listed are those that accounted for five or more cases of IPD in 2016.

[h] Total number of isolates from culture-positive cases referred to ESR for serotyping for each age group.

Trends in the rates of disease due to PCV7 serotypes, the additional serotypes covered by PCV10 (1, 5, 7F and cross-reactive 19A) and PCV13 (3 and 6A), and all other serotypes for the different age groups are presented in Figure 5. Since the introduction of PCV7 to the national immunisation schedule in 2008 and the change to PCV10 in 2011, there have been significant decreases in IPD rates due to PCV10 serotypes in all age groups, with a greater decrease for PCV7 serotypes. The largest decreases for PCV7 serotypes have been in the <2 years and 2–4 years age groups, with 100.0% and 96.5% reductions in the rates between 2006/07 and 2016, respectively, in these two age groups, resulting in a 99.2% reduction in the combined <5 years age group. However, as there were no cases in the <2 years and only one case in the 2–4 years age groups in 2016 the rates are considered unstable. The reductions over the same time period in the older age groups have also been significant, at 79.5% in the 5–64 years age group and 87.7% in the ≥65 years group. Data is presented for each of the age groups in the appendices in Table 24, Table 25, Table 26 and Table 27, and for all age groups in Table 28.

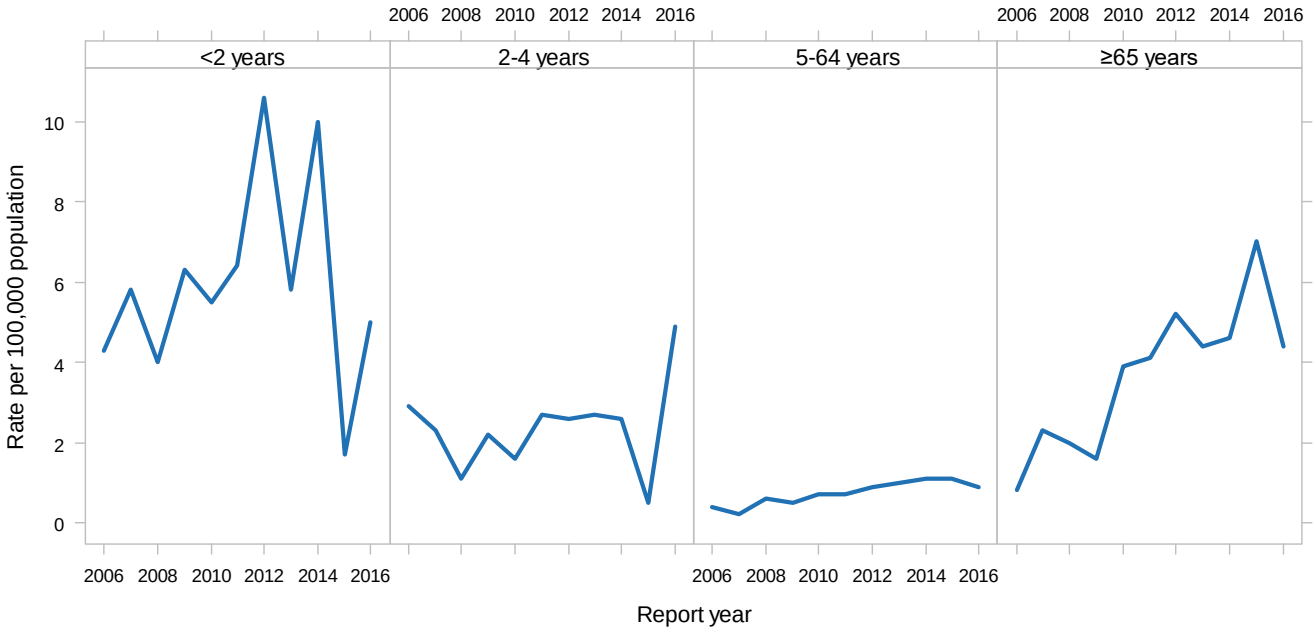
Figure 5. Rate per 100,000 population of invasive pneumococcal disease due to PCV7 serotypes, additional PCV10 types, additional PCV13 types and non-PCV13 types, by age group and year, 2006–2016



Note: 'PCV7 serotypes' are cases due to serotypes covered by PCV7 (4, 6B, 9V, 14, 18C, 19F and 23F); 'Serotypes 1, 5 and 7F' are cases due to the additional serotypes covered by PCV10; 'Serotypes 3, 6A and 19A' are cases due to the additional serotypes covered by PCV13; and 'Other serotypes' are all other culture-positive IPD cases that were typed. Data presented from 2009 is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD.

In 2016, there were a total of 78 IPD cases due to serotype 19A – more than twice the number of any other serotype. Serotype 19A was the most prevalent serotype in the 5–64 and ≥65 years age groups (Table 9). Since 2006, there have been significant increases in the rate of 19A disease in the 5–64 years (0.4 to 0.9 per 100,000) and ≥65 years [0.8 (rate based on 4 cases) to 4.4 per 100,000] age groups (Figure 6 and Table 29 in the Appendix). From 2011 to 2016 case numbers and rates of 19A IPD cases have continued to fluctuate in the <2 years age group. The substantial decrease to two cases in 2015 from 12 cases (10.0 per 100,000) in 2014 was followed by an increase in 2016 to six cases (5.0 per 100,000).

Figure 6. Rate per 100,000 population of invasive pneumococcal disease due to serotype 19A by age group and year, 2006–2016

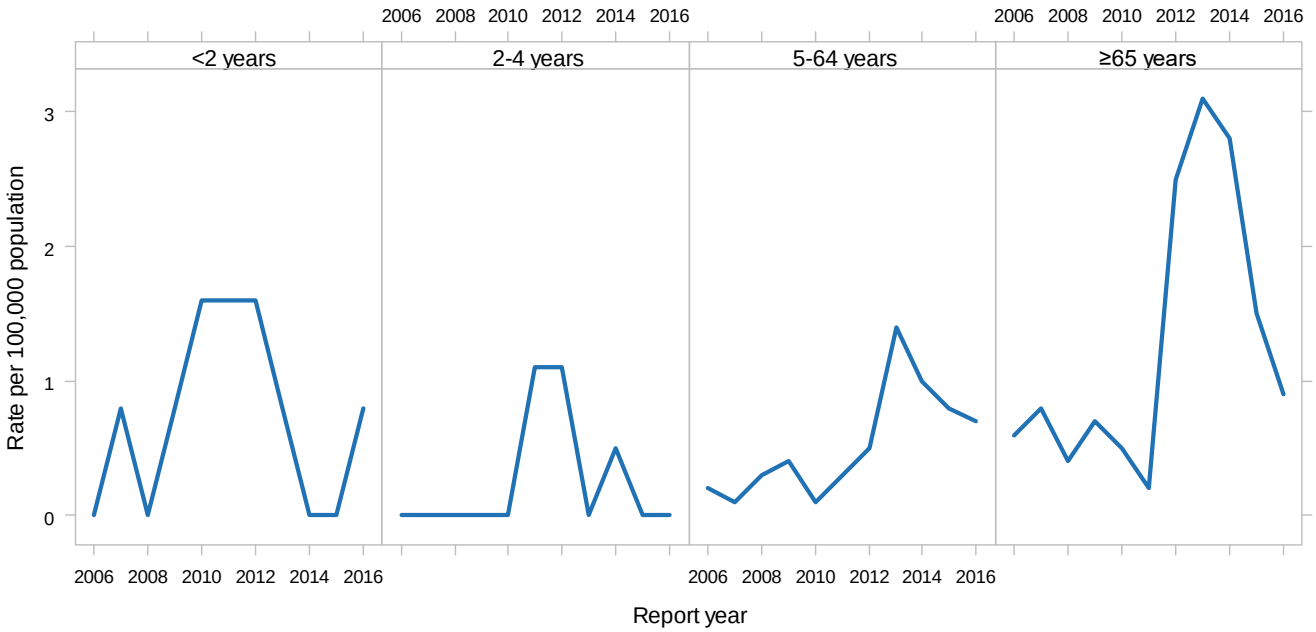


Note: Data presented from 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD. Rates for the <2 are based on less than five cases and are considered unstable.

The other common serotypes in 2016 were 22F (39 cases), 7F (33 cases), 8 (29 cases) and 3 (27 cases) (Table 9). Of these, 7F is covered by both PCV10 and PCV13 vaccines and serotype 3 is covered by PCV13.

Although rates of IPD due to the PCV10 serotype 7F increased in the 5–64 years and ≥65 years age groups between 2011 and 2013, the rate has decreased yearly since 2014 in both age groups (Figure 7 and Table 30 in the Appendix).

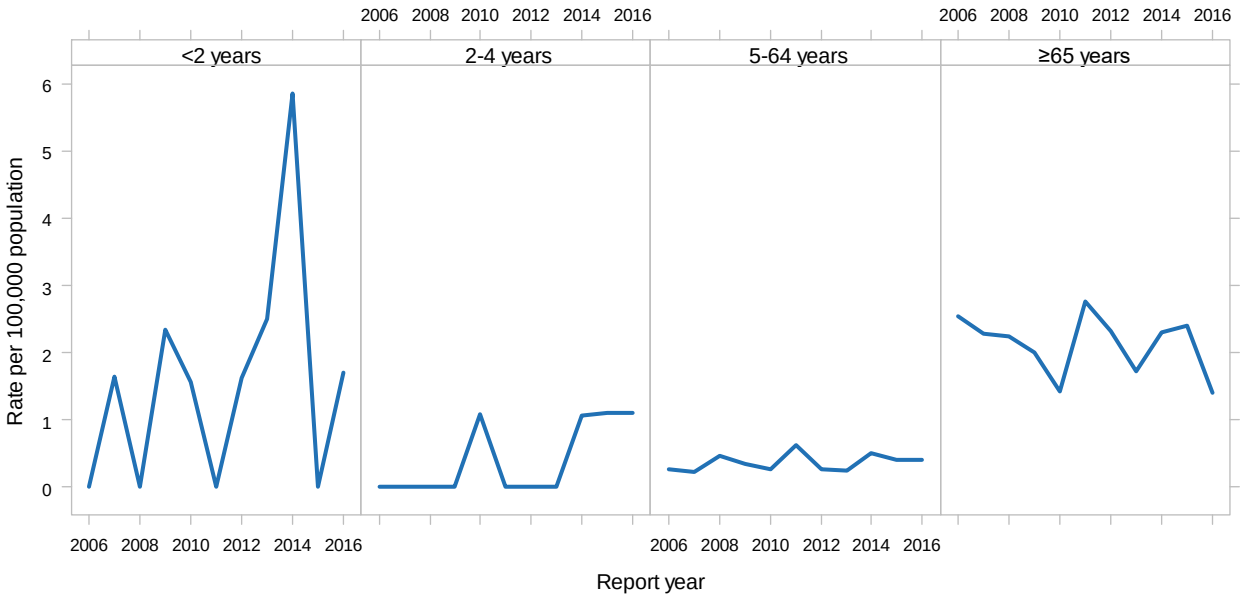
Figure 7. Rate per 100,000 population of invasive pneumococcal disease due to serotype 7F by age group and year, 2006–2016



Note: Data presented from 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD. Rates for the <2 and 2–4 years are based on less than five cases and are considered unstable.

Although there was a notable increase in the prevalence of the PCV13 serotype 3 in 2014, (23 in 2013 to 42 in 2014), particularly in the <65 years age groups, total case numbers have steadily decreased since 2015 to 27 cases in 2016 (Figure 8). The number of cases in the <2 age group has decreased to two cases in 2016 from seven in 2014 (Table 24, Table 25, Table 26 and Table 27 in the Appendix).

Figure 8. Rate per 100,000 population of invasive pneumococcal disease due to serotype 3 by age group and year, 2006–2016



Note: Data presented from 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD. Rates for the <2 and 2–4 years are based on less than five cases for all years apart from 2014 and are considered unstable.

ANTIMICROBIAL SUSCEPTIBILITY

Table 10 shows the antimicrobial susceptibility of the 455 isolates from culture-positive IPD cases referred to ESR in 2016. The penicillin and cefotaxime MIC distributions are presented in Table 31 (Appendix). 23.5% of isolates were resistant to penicillin (meningitis breakpoints) and 0.9% were cefotaxime resistant. Among the penicillin-resistant isolates (meningitis breakpoints), 15.9% (17/107) were multiresistant to at least three additional antibiotics, most commonly co-trimoxazole, erythromycin and tetracycline.

Rates of penicillin resistance, cefotaxime resistance and multidrug resistance over the last 10 years (2007–2016) are presented in Table 32 (Appendix). Due to the change to EUCAST susceptibility testing methods in 2016, the results for 2016 are not all directly comparable with those for earlier years. However, the rates of penicillin resistance (based on the CLSI and EUCAST meningitis resistance breakpoint of MIC ≥0.12 mg/L) and the rates of cefotaxime resistance (based on the CLSI non-meningitis resistance breakpoint and the EUCAST resistance breakpoint of MIC ≥4 mg/L) are comparable and therefore trends in these rates of resistance for the 2007–2016 period were compared. Penicillin resistance has varied year-to-year from a high of 23.5% in 2016 to a low of 14.1% in 2011, but there has been no significant trend over the 10 years. Likewise, there has been no significant change over the last 10 years in rates of cefotaxime resistance. The rate of 0.9% cefotaxime resistance in 2016 was within the range (0.4–2.1%) recorded for other years during the last decade.

Resistance to the non-β-lactam antibiotics over the last 10 years is presented in Table 33 (Appendix). All isolates remain susceptible to vancomycin and moxifloxacin. Rifampicin susceptibility has been tested since 2010, with no resistance identified.

Table 10. Antimicrobial susceptibility among isolates from invasive pneumococcal disease cases, 2016

Antibiotic	EUCAST clinical breakpoints[a]			Susceptibility (%)		
	S[b]	I[b]	R[b]	S[b]	I[b]	R[b]
	Minimum inhibitory concentration (MIC, mg/L)					
Penicillin						
meningitis	≤0.06	-	≥0.12	76.5	-	23.5
non-meningitis[c]	≤0.06	0.12–2	≥4	76.5	22.2	1.3
Cefotaxime	≤0.5	1–2	≥4	97.1	2.0	0.9
	Zone diameter (mm)					
Chloramphenicol	≥21	-	≤20	99.1	-	0.9
Clindamycin[d]	≥19	-	≤18	92.7	-	7.3
Co-trimoxazole	≥18	15–17	≤14	74.3	4.2	21.5
Erythromycin	≥22	19–21	≤18	88.4	0.0	11.6
Moxifloxacin	≥22	-	≤21	100.0	-	0.0
Rifampicin	≥22	17–21	≤16	100.0	0.0	0.0
Tetracycline	≥25	22–24	≤21	91.6	0.2	8.1
Vancomycin	≥16	-	≤15	100.0	-	0.0

[a] European Committee on Antimicrobial Susceptibility Testing.[21]

[b] S: susceptible, I: intermediate, and R: resistant.

[c] EUCAST also provide several additional dose-specific penicillin breakpoints for pneumonia. Based on the susceptible breakpoint (MIC ≤0.5) for a dose of 1.2 g 6 hourly, 94.7% of isolates would be categorised as susceptible.

[d] The percentage resistant given is for constitutive clindamycin resistance. No isolates had inducible clindamycin resistance.

Penicillin and cefotaxime resistance in each region and DHB is presented in Table 34 (Appendix). Regional rates of penicillin resistance (meningitis breakpoints) ranged from a low of 12.7% in the Central region to a high of 29.6% in the Northern region, and the difference between these two regions was significant (*p* 0.005).

Penicillin and cefotaxime resistance among isolates from cases in the different age groups is shown in Table 11. Penicillin resistance was significantly higher among isolates from cases <5 years old (*p* 0.029).

Table 11. Penicillin and cefotaxime resistance among isolates from invasive pneumococcal disease cases, 2016

Age group (years)	Penicillin		Cefotaxime			
	Resistant[a] MIC ≥0.12 mg/L		Intermediate MIC 1-2 mg/L		Resistant MIC ≥4 mg/L	
	Number	%[b]	Number	%[b]	Number	%[b]
<2 (n=19)	7	36.8	2	10.5	0	-
2−4 (n=21)	8	38.1	1	4.8	0	-
5−64 (n=233)	49	21.0	2	0.9	2	0.9
>65 (n=182)	43	23.6	4	2.2	2	1.1
All ages (n=455)	**107**	**23.5**	**9**	**1.3**	**4**	**0.9**

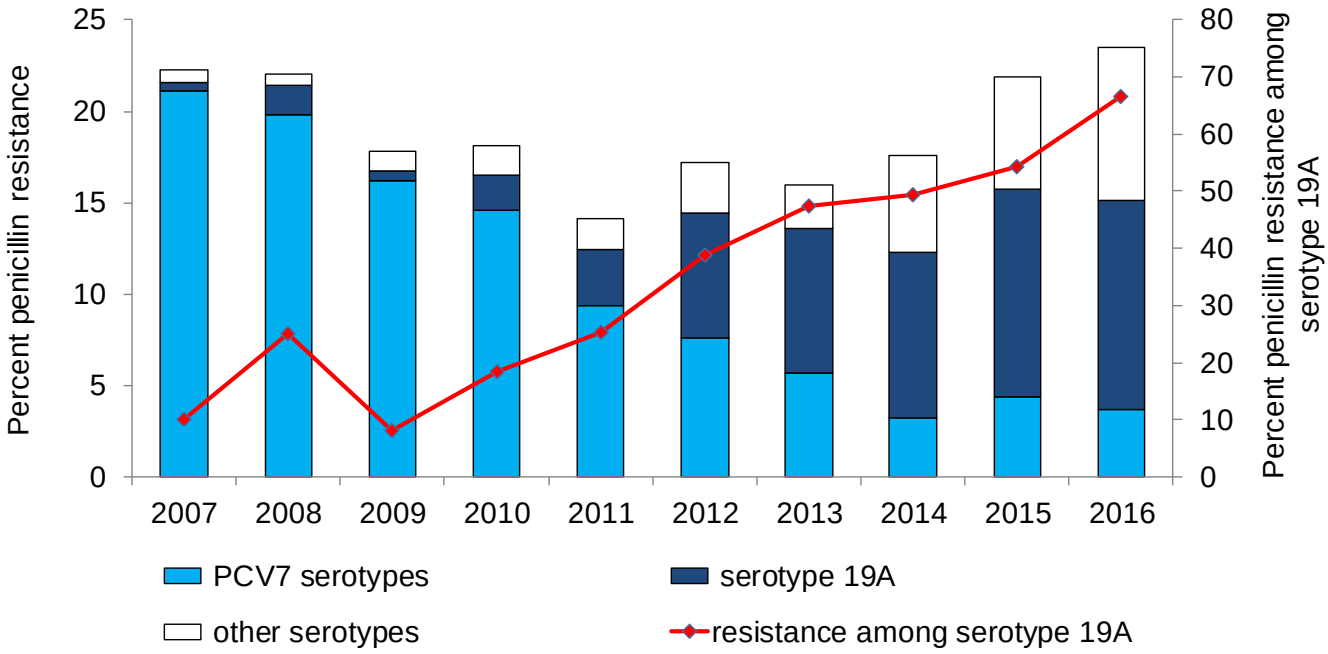
[a] EUCAST meningitis breakpoints; no intermediate category [21].

[b] Percentage of the isolates from the cases within the age group.

Since the introduction of PCV into the childhood immunisation schedule, the serotype distribution among penicillin-resistant invasive pneumococci has changed markedly, with a steady decline in the proportion of penicillin resistance due to PCV7 types (Figure 8). In 2006–2007, PCV7 types accounted for 92.8% of the penicillin resistance compared with just 15.9% in 2016 (Table 35 in the Appendix). Conversely other serotypes, especially type 19A, now account for the majority of penicillin-resistant invasive pneumococci. In 2016 serotype 19A accounted for 48.6% of the penicillin-resistant invasive pneumococci (Figure 8 and Table 35 in the Appendix). The prevalence of penicillin resistance among serotype 19A isolates has increased significantly in recent years from an average of 15.8% in 2006–2007 to 66.7% in 2016 (Figure 8 and Table 36 in the Appendix).

In contrast to serotype 19A being the most prevalent type among penicillin-resistant invasive pneumococci in 2016, all four cefotaxime-resistant isolates were type 19F. Together types 19F and 19A accounted for 70.6% (12/17) of the multiresistant invasive pneumococci (Table 35 in the Appendix).

Figure 9. Penicillin-resistance among pneumococci from invasive disease cases, 2007–2016



Note: The bar chart and scale on the left-hand vertical axis show the percentage of pneumococcal isolates from invasive disease that were penicillin resistant (meningitis breakpoints). Each bar is split to indicate the proportion of the penicillin-resistant isolates that were PCV7 serotypes, the proportion that were serotype 19A and the proportion that were other serotypes. The line graph and scale on the right-hand vertical axis show the percentage of serotype 19A isolates that were penicillin resistant.

DISCUSSION

It has been eight full year since the first IPD vaccine (PCV7) was introduced into the New Zealand childhood immunisation (in June 2008) and the impact of routine childhood immunisation is evident across all age groups with the overall notification rate for IPD decreasing by 37.0% between 2009 and 2016.

The direct impact of vaccination can be seen in significant declines in IPD cases in children <5 years of age, with a 71.8% reduction in the average rate reported for 2006–2007 to the 2016 rate (53.5 to 15.1 per 100,000). It is of interest that while the addition of pleural fluid antigen detection to the case definition in 2016 resulted in only two additional cases notified in the <5 years age group, this increased the rate from 14.4 to 15.1 per 100,000 for this age group. The indirect impact of the childhood immunisation programme can be seen in the notification rates in older age groups due to reduced carriage and transmission of *S. pneumoniae.* Using 2009 as a baseline year (first year of notification-based surveillance), overall rates have decreased significantly between 2009 and 2016 by 36.8% and 37.1% in the 5–64 and ≥65 years age groups, respectively (10.3 to 6.5 per 100,000 and 44.0 to 27.6 per 100,000).

Māori and Pacific peoples remain disproportionately burdened with IPD across all age groups and in 2016 the age-standardised rates of IPD in Pacific peoples and Māori were 5.7 and 3.8 times that of the European and Other ethnic group. Although the rate in the <5 and 5–64 years age groups decreased in Pacific peoples between 2009 and 2016, the overall rate has not decreased in this time period (39.9 to 40.0 per 100,000), and Pacific peoples have experienced the highest rates of all ethnic groups since 2010. In contrast the overall rate in Māori has declined by 19.3% since 2009 (33.2 to 26.8 per 100,000), with a decrease in rates reported in all age groups apart from those aged 65 years or older. In 2016 over half the cases (54.5%, 12 of 22 cases) in the <2 years age group were in the Māori and Pacific peoples ethnic groups. The unequal burden of IPD in Māori and Pacific peoples is consistent with reports from other countries of the persistence of ethnic disparities in the incidence of IPD despite overall reductions in disease following the introduction of PCV.[22, 23]

While the rate of IPD has decreased in all deprivation levels since 2009, there remains a trend of higher rates of IPD with greater levels of deprivation. In 2016, the rate in the most deprived (quintile 5) was 3.3 times that of the least deprived (quintile 1), an increase from 2.4 times the year before.

Since the vaccine was introduced in 2008, schedule changes have replaced PCV7 with PCV10 in 2011, PCV10 with PCV13 in 2014 and in July 2017, PCV10 will be re-introduced to the childhood immunisation schedule replacing PCV13. The overall impact of the addition of PCV7 and then PCV10 to the childhood immunisation schedule is shown by the reduction in the rate of IPD due to these vaccine serotypes by 88.3% and 66.0%, respectively, across all age groups from the 2006–2007 average rate to that reported in 2016. The rates in the <5 years age group due to these vaccine serotypes have declined by 99.2% and 88.4% from the 2006–2007 average rate. Herd immunity for serotypes covered by PCV7 and PCV10 has accumulated over time in the 5–64 and ≥65 age groups with reductions in the rate of IPD due to PCV10 serotypes of 48.7% and 67.5% respectively between the 2006– 2007 average rate to that reported in 2016. In both these

age groups it is also clear that the serotypes responsible for disease have changed with a decrease in the proportion of vaccine serotypes compared with other serotypes.

Each change of PCV type on the immunisation schedule has caused shifts in the predominant serotypes causing IPD. There have been significant declines in the PCV7 and PCV10 serotypes since the introduction of each vaccine, particularly in the <2 and 2–4 years age groups. After each vaccine introduction there have been the expected increases in the proportion of IPD cases caused by non-vaccine strains, and in 2016 54.3% of cases were caused by non-PCV serotypes. This phenomenon of serotype replacement is observed in many countries although the most prevalent replacement serotypes differ between them.[24] Despite concerns raised that replacement serotypes could diminish the value of PCV immunisation,[24] the overall rates of IPD in New Zealand have continued to decline.

The most prevalent serotypes in 2016 were 19A (PCV10 through cross-reactive antibodies from 19F)), 22F (non-PCV), 7F (PCV10), 8 (non-PCV), and 3 (PCV13). These collectively accounted for 45.3% of all IPD cases (206/455).

Following the introduction of PCV in New Zealand serotype 19A became the predominant serotype in 2011, a trend also seen in other countries.[25] This type is important because it has a greater potential to cause invasive pneumococcal disease compared with other serotypes [25] and has the highest rate of antibiotic resistance of all isolates in New Zealand. Following the introduction of PCV10 in 2011, the rate of IPD due to serotype 19A has fluctuated in the <5 years age group, with a five-fold increase from 2015 to 2016 (3 to 15 cases). However, the small numbers make trend interpretation difficult. There has been little change in the rate in the 5–64 years age group, and some fluctuation in the ≥65 age group but no overall trend. In 2016, the highest rate of IPD caused by type 19A was in the <2 years age group (5.0 per 100,000, 6 cases), an increase from two cases in 2015 and 19A serotypes caused 17.1% of all IPD cases. The proportion of penicillin-resistant isolates has been increasing every year since 2011, and in 2016 19A accounted for 48.6% of the penicillin-resistant invasive pneumococci, and 66.7% of all 19A isolates were penicillin-resistant.

Serotype 22F (included in 23PPV) is the most prevalent serotype in the ≥65 years age group. In this age group the 2016 rate of IPD caused by serotype 22F increased from the average rate of 0.9 in 2006–2007 to 2.9 per 100,000. Immunisation with 23PPV is recommended, but unfunded, for this age group, (apart from re-vaccination in some high risk groups).[2]

Since the notable increase in IPD caused by type 7F in the 5–64 and ≥65 age groups between 2011 and 2013, the rate has been decreasing steadily. This is probably because of greater herd immunity over time as coverage of infants with PCV10 and PCV13 vaccines increased.[26, 27]

Serotype 8 is included in 23PPV and is most prevalent in those >5 years of age. The number of cases in the 5–64 years age group was relatively stable from the average for 2006–2007 to 2015, but then more than doubled in 2016 (12 to 25 cases). However, the rate remains less than one per 100,000. In contrast, from 2006 to 2016 the number of cases in the ≥65 years age group has remained stable ranging between four and seven cases.

The number of cases caused by serotype 3, which is included in PCV13, nearly doubled in number from 2013 to 2014 to 42 cases. Research suggests that PCV13 confers minimal protection against serotype 3, even after sustained use.[28, 29] Despite this, following the widespread use of PCV13 at the beginning of 2015, the number of cases due to type 3 declined from 42 in 2014 to 27 in 2016 (0.9 to 0.6 per 100,000) and there were only two cases in the <2 years age group in 2016, compared with seven cases in 2014. Since the introduction of PCV13 the rate in the 5–64 age group has remained unchanged (0.4 per 100,000) and has declined in the ≥65 age group (2.4 to 1.4 per 100,000). It seems unlikely that the decrease in the older age group is due to the addition of PCV13 to the childhood immunisation schedule in 2014 as insufficient time has passed for indirect protection to be conferred [27] and evidence suggests little impact from PCV13 to reduce serotype 3 carriage.[30, 31]

There were 10 apparent vaccine failures in 2016 with all cases having completed the routine childhood immunisation schedule with at least the last dose being a vaccine that covered the serotype responsible for their disease. Eight of these cases were due to serotype 19A, of whom two were reported to have underlying chronic health conditions. While this is an increase from 2015, the change in the definition of vaccine failure along with the acceptance that PCV10 provides cross-reactive coverage against 19A means that the number of vaccine failures are not directly comparable. However, under the new conditions there would have been only one failure due to serotype 19A in 2015. The remaining two cases were due to serotype 3.

PCV immunisation has resulted in significant decreases in the rates of IPD across all age groups in New Zealand. Predictions suggest that a sustained childhood immunisation programme using PCV13 would confer a similar level of indirect protection in the 5–64 and ≥65 age groups that was seen for PCV7 serotypes.[32, 33] In 2017, a schedule change will replace PCV13 with PCV10. Ongoing surveillance will be crucial for monitoring the impact of this change. It will be especially important to monitor serotype 19A to demonstrate whether recent reductions in rates of disease with this serotype are maintained.

REFERENCES

1. Institute of Environmental Science and Research (ESR). 2014. *Invasive pneumococcal disease in New Zealand, 2013.* Porirua: ESR.
2. Ministry of Health. 2018. *Immunisation Handbook 2017 (2nd Edition).* Wellington: Ministry of Health.
3. Heffernan H, Martin D. 2009. *Invasive pneumococcal disease in New Zealand, 2008.* Porirua, NZ: Institute of Environmental Science and Research Ltd (ESR).
4. Heffernan H, Morgan J, Woodhouse R, et al. 2010. *Invasive pneumococcal disease in New Zealand, 2009.* Porirua, NZ: Institute of Environmental Science and Research Ltd (ESR).
5. Heffernan H, Morgan J, Woodhouse R. 2011. *Invasive pneumococcal disease in New Zealand, 2010.* Porirua, NZ: Institute of Environmental Science and Research Ltd (ESR).
6. Lim E, Heffernan H. 2012. *Invasive pneumococcal disease in New Zealand, 2011.* Porirua, NZ: Institute of Environmental Science and Research Ltd (ESR).
7. Lim E, Heffernan H. 2013. *Invasive pneumococcal disease in New Zealand, 2012.* Porirua, NZ: Institute of Environmental Science and Research Ltd (ESR).
8. Institute of Environmental Science and Research (ESR). 2015. *Invasive Pneumococcal Disease in New Zealand, 2014.* Porirua, NZ: The Institute.
9. Institute of Environmental Science and Research (ESR). 2016. *Invasive Pneumococcal Disease in New Zealand, 2015.* Porirua, NZ: The Institute.
10. Green MJ, Cawley PF. In vitro antimicrobial susceptibility of *Streptococcus pneumoniae* in New Zealand. *NZ Med J* 1979;90(640):53-5.
11. Heffernan H. Antimicrobial susceptibility of clinically significant *Streptococcus pneumoniae* isolates. *NZ Med J* 1987;100(824):327.
12. Martin D, Brett M. Pneumococci causing invasive disease in New Zealand, 1987-94: serogroup and serotype coverage and antibiotic resistances. *NZ Med J* 1996;109(1027):288-90.
13. Brett M, Martin D. A significant increase in antimicrobial resistance among pneumococci causing invasive disease in New Zealand. *NZ Med J* 1999;112(1085):113-5.
14. Heffernan H, Martin D, Woodhouse R, et al. Invasive pneumococcal disease in New Zealand 1998-2005: capsular serotypes and antimicrobial resistance. *Epidemiol Infect* 2008;136(3):352-9.
15. Ministry of Health. 2012. *Communicable Disease Control Manual 2012.* Wellington, NZ: Ministry of Health.
16. Lund E, Henrichsen J. 1978. Laboratory diagnosis, serology and epidemiology of *Streptococcus pneumoniae*, in Methods in microbiology. 12th ed. Bergan T, Norris R (eds). London: Academic Press.
17. European Committee on Antimicrobial Susceptibility Testing.*Antimicrobial susceptibility testing. EUCAST disk diffusion method. Version 5.0 (January 2015). .* Available from: http://eucast.org/. Accessed.
18. European Committee on Antimicrobial Susceptibility Testing.*Breakpoint tables for the interpretation of MICS and zone diameters. Version 6.0, 2016.* Available from: http://eucast.org/. Accessed.
19. Ministry of Health. 2017. *Immunisation Handbook 2017.* Wellington: Ministry of Health.

20. PTAC Immunisation subcommittee. 2017. *Immunisation Subcommittee of PTAC Minutes of meeting held 23 May 2016.* Available from: https://www.pharmac.govt.nz/assets/ptac-immunisation-subcommittee-minutes-2016-05.pdf. Accessed March.
21. Clinical and Laboratory Standards Institute, *Performance standards for antimicrobial disk susceptibility tests; approved standard- twelth edition*. 2015, CLSI: Wayne, PA, USA.
22. Bareja C, Toms C, Lodo K, et al. Invasive pneumococcal disease in Australia, 2009 and 2010. *Commun Dis Intell* 2015;39:E265-79.
23. Wortham J, Zell E, Pondo T, et al. Racial disparities in invasive *Streptococcus pneumoniae* infections, 1998-2009. *Clin Infect Dis* 2014;58(9):1250-7.
24. Weinberger DM, Malley R, Lipsitch M. Serotype replacement in disease after pneumococcal vaccination. *The Lancet* 2011;378(9807):1962-1973.
25. Isturiz R, Sings HL, Hilton B, et al. Streptococcus pneumoniae serotype 19A: worldwide epidemiology. *Expert Rev Vaccines* 2017;16(10):1007-1027.
26. Pilishvili T, Lexau C, Farley MM, et al. Sustained reductions in invasive pneumococcal disease in the era of conjugate vaccine. *J Infect Dis* 2010;201(1):32-41.
27. Miller E, Andrews NJ, Waight PA, et al. Herd immunity and serotype replacement 4 years after seven-valent pneumococcal conjugate vaccination in England and Wales: an observational cohort study. *Lancet Infect Dis* 2011;11(10):760-8.
28. Moore M, Link-Gelles R, Schaffner W. Effect of use of 13-valent pneumococcal conjugate vaccine in children on invasive pnemococcal disease in children and adults in the USA: analysis of multisite, population-based surveillance. *Lancet Infect Dis.* 2015;15:301-9.
29. Andrews N, Waight P, Burbidge P, et al. Serotype-specific effectiveness and correlates of protection for the 13-valent pneumococcal conjugate vaccine: a postlicensure indirect cohort study. *Lancet Infect Dis.* 2014;14(9):839-846.
30. Dagan R PS, Juergens C et al. Comparative Immunogenicity and Efficacy of 13-Valent and 7-Valent Pneumococcal Conjugate Vaccines in Reducing Nasopharyngeal Colonization: A Randomized Double-Blind Trial. *Clin Infect Dis* 2013;57(7):952-62.
31. Kandasamy R VM, Collins S et al. Persistent circulation of vaccine serotypes and serotype replacement after five years of UK infant immunisation with PCV13. *J Infect Dis* 2019.
32. Shiri T, Datta S, Madan J, et al. Indirect effects of childhood pneumococcal conjugate vaccination on invasive pneumococcal disease: a systematic review and meta-analysis. *Lancet Glob Health* 2017;5(1):e51-e59.
33. Waight P, Andrews N, Ladhani S, et al. Effect of the 13-valent pneumococcal conjugate vaccine on invasive pneumococcal disease in England and Wales 4 years after its introduction: an observational cohort study. *Lancet Infect Dis* 2015;15:535-43.

APPENDIX

CASE REPORT FORM **Invasive Pneumococcal Disease**

Invasive pneumococcal disease EpiSurv No.

Reporting Authority

Name of Public Health Officer responsible for case

Notifier Identification

Reporting source* ○ General Practitioner ○ Hospital-based Practitioner ○ Laboratory ○ Self-notification ○ Outbreak Investigation ○ Other

Name of reporting source **Organisation**

Date reported* **Contact phone**

Usual GP **Practice** **GP phone**

GP/Practice address Number Street Suburb Town/City Post Code ☐ GeoCode

Case Identification

Name of case* Surname Given Name(s)

NHI number* **Email**

Current address* Number Street Suburb Town/City Post Code ☐ GeoCode

Phone (home) **Phone (work)** **Phone (other)**

Case Demography

Location **TA*** **DHB***

Date of birth* **OR** **Age** ○ Days ○ Months ○ Years

Sex* ○ Male ○ Female ○ Indeterminate ○ Unknown

Occupation*

Occupation location ○ Place of Work ○ School ○ Pre-school

Name

Address Number Street Suburb Town/City Post Code ☐ GeoCode

Alternative location ○ Place of Work ○ School ○ Pre-school

Name

Address Number Street Suburb Town/City Post Code ☐ GeoCode

Ethnic group case belongs to* (tick all that apply)

☐ NZ European ☐ Maori ☐ Samoan ☐ Cook Island Maori

☐ Niuean ☐ Chinese ☐ Indian ☐ Tongan

☐ Other (such as Dutch, Japanese, Tokelauan) *(specify)

Invasive pneumococcal disease EpiSurv No.

Basis of Diagnosis

CLINICAL PRESENTATION*

Pneumonia	○ Yes	○ No	○ Unknown
Bacteraemia without focus	○ Yes	○ No	○ Unknown
Meningitis	○ Yes	○ No	○ Unknown
Empyema	○ Yes	○ No	○ Unknown
Septic arthritis	○ Yes	○ No	○ Unknown
Other	○ Yes	○ No	○ Unknown

If other, specify _____

LABORATORY CRITERIA

Specimen* (tick all with positive results)

Blood	☐ culture		☐ NAAT[2]	[1] refer to the case report form instructions
CSF	☐ culture	☐ antigen detection[1]	☐ NAAT	[2] nucleic acid amplification test
Pleural fluid	☐ culture	☐ antigen detection[1]	☐ NAAT	
Joint fluid	☐ culture		☐ NAAT	
Other sterile site specimen	☐ culture		☐ NAAT	

(specify) _____

STATUS* ○ Under investigation ○ Confirmed ○ Not a case

ADDITIONAL LABORATORY DETAILS

Capsular type* _____

ESR Updated ☐ Laboratory _____

Date result updated _____ Sample Number _____

Clinical Course and Outcome

Date of onset*		☐ Approximate	☐ Unknown
Hospitalised*	○ Yes	○ No	○ Unknown
Date hospitalised*		☐ Unknown	
Hospital*			
Died*	○ Yes	○ No	○ Unknown
Date died*		☐ Unknown	

Was this disease the primary cause of death?* ○ Yes ○ No ○ Unknown

If no, specify the primary cause of death*

Outbreak Details

Is this case part of an outbreak (i.e. known to be linked to one or more other cases of the same disease)?*

☐ Yes **If yes, specify Outbreak No.***

Invasive pneumococcal disease EpiSurv No.

Risk Factors

Premature <37 weeks gestation (if case is <1 year of age)* ○ Yes ○ No ○ Unknown

Congenital or chromosomal abnormality (*includes Down's syndrome*)* ○ Yes ○ No ○ Unknown

Chronic lung disease or Cystic Fibrosis* ○ Yes ○ No ○ Unknown

Anatomical or functional asplenia* ○ Yes ○ No ○ Unknown

Immunocompromised* ○ Yes ○ No ○ Unknown

Includes HIV/AIDS, lymphoma, organ transplant, multiple myeloma, nephrotic syndrome, chronic drug therapy (e.g. chemotherapy or >20 mg/d prednisolone in last year), dysgammaglobulinaemia and sickle cell anaemia.

Chronic illness* ○ Yes ○ No ○ Unknown

Includes CSF leak, intracranial shunts, diabetes, cardiac disease (angina, MI, heart failure, coronary bypass), pulmonary disease (asthma, bronchitis, emphysema), chronic liver disease, renal impairment and alcohol related.

Cochlear implants* ○ Yes ○ No ○ Unknown

Current smoker* ○ Yes ○ No ○ Unknown

Smoking in the household (if case is <5 years of age)* ○ Yes ○ No ○ Unknown

Attends childcare (if case is <5 years of age)* ○ Yes ○ No ○ Unknown

Attends childcare (regular attendance >4 hours per week) in a grouped childcare setting outside the home.

Resident in long term or other chronic care facility* ○ Yes ○ No ○ Unknown

Other risk factors including illness that requires regular medical review (specify)*

_____

Protective Factors

At any time prior to onset, had the case been immunised with the pneumococcal polysaccharide or pneumococcal conjugate vaccine?* ○ Yes ○ No ○ Unknown

If yes, specify vaccination details*

Source of information* ○ Patient/caregiver recall ○ Documented

Dose 1:* ○ Polysaccharide ○ Conjugate ○ Unknown

Date given* Or age when first dose was given ○ Weeks ○ Months ○ Years

Dose 2:* ○ Polysaccharide ○ Conjugate ○ Not given ○ Unknown

Date given* _____ Or age when second dose was given ___ ○ Weeks ○ Months ○ Years

Dose 3:* ○ Polysaccharide ○ Conjugate ○ Not given ○ Unknown

Date given* _____ Or age when third dose was given ___ ○ Weeks ○ Months ○ Years

Dose 4:* ○ Polysaccharide ○ Conjugate ○ Not given ○ Unknown

Date given* Or age when fourth dose was given ○ Weeks ○ Months ○ Years

Dose 5:* ○ Polysaccharide ○ Conjugate ○ Not given ○ Unknown

Date given* Or age when fifth dose was given ○ Weeks ○ Months ○ Years

Dose 6:* ○ Polysaccharide ○ Conjugate ○ Not given ○ Unknown

Date given* _____ Or age when sixth dose was given ___ ○ Weeks ○ Months ○ Years

NIR Vaccination Status (to be completed by ESR)

○ Fully vaccinated for age ○ Partially vaccinated for age ○ Not vaccinated ○ Not applicable

Date status updated _____ NIR Reference _____

Table 12. Laboratory criteria upon which invasive pneumococcal disease diagnosis was based, as recorded in the case notification, 2016

Basis of diagnosis	Prioritised[a]		Total response	
	Cases	%[b]	Cases	%[b]
Culture of *S. pneumoniae* from	**473**	**98.5**	**473[c]**	**98.5**
CSF	22	4.6	22	4.6
Blood	424	88.3	432	90.0
Pleural fluid	13	2.7	14	2.9
Joint fluid	6	1.3	15	3.1
Other normally sterile site[d]	8	1.7	10	2.1
Positive pneumococcal antigen test on	**6**	**1.2**	**15**	**3.1**
CSF	3	0.6	11	2.3
Pleural fluid	3	0.6	4	0.8
Detection of pneumococcal DNA	**1**	**0.2**	**1**	**0.2**
CSF	0	-	0	-
Blood	0	-	0	-
Pleural fluid, joint fluid and other	1[e]	0.2	1	0.2

[a] For several cases, more than one method of laboratory confirmation was recorded. In the prioritised analysis, only one method of laboratory confirmation was counted for each case, with methods prioritised in the following order: culture of *S. pneumoniae* from CSF, culture of *S. pneumoniae* from blood, detection of *S. pneumoniae* DNA in CSF, positive pneumococcal antigen test on CSF, detection of *S. pneumoniae* DNA in blood, culture of *S. pneumoniae* from pleural fluid, culture of *S. pneumoniae* from joint fluid, culture of *S. pneumoniae* from another normally sterile site, detection of *S. pneumoniae* DNA in pleural fluid, positive pneumococcal antigen test of pleural fluid, detection of *S. pneumoniae* DNA in joint fluid, and detection of *S. pneumoniae* DNA in other normally sterile site.

[b] Percent of total 480 cases.

[c] Number of cases that had *S. pneumoniae* cultured from any normally sterile site.

[d] Includes seven different sterile sites.

[e] Detection of DNA in pleural fluid.

Figure 10. Number of invasive pneumococcal disease cases in the <2 years age group by age (in months), 2016

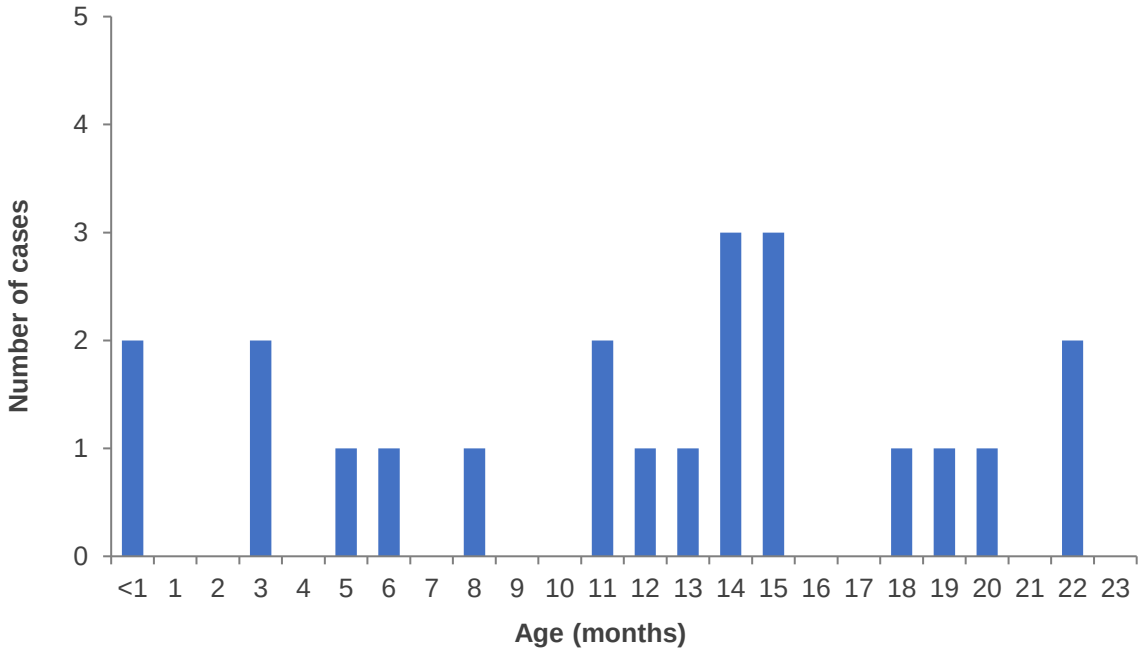


Table 13. Number of cases and rate per 100,000 population of invasive pneumococcal disease by age group and year, 2006–2007 average, 2009–2016

Age group (years)	2006–2007 average		2009		2010		2011		2012		2013		2014		2015		2016	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
<1	59.5	98.2	34	53.2	22	34.1	23	36.6	31	50.7	18	29.9	22	37.4	10	16.9	9	15.2
1	59.5	102.2	25	38.9	15	23.5	7	10.8	13	20.7	6	9.8	12	19.8	4	6.7	13	21.7
2–4	35.5	20.8	41	22.9	28	15.1	18	9.5	14	7.3	16	8.4	21	11.1	10	5.3	24	12.9
5–14	24.5	4.1	58	9.8	23	3.9	29	4.9	20	3.4	26	4.4	18	3.0	10	1.6	16	2.6
15–24	17.0	2.8	53	8.7	25	4.1	27	4.3	21	3.4	23	3.7	19	3.0	18	2.7	25	3.7
25–34	20.0	3.7	53	9.8	25	4.6	40	7.4	24	4.4	18	3.3	24	4.2	22	3.7	26	4.1
35–44	47.5	7.5	68	10.9	39	6.3	36	5.9	37	6.1	36	6.1	36	6.1	26	4.5	26	4.5
45–54	39.5	6.9	55	9.0	59	9.6	55	8.9	44	7.1	62	9.9	50	8.0	57	9.0	60	9.4
55–64	59.5	13.7	69	14.7	75	15.5	87	17.5	74	14.7	87	17.0	69	13.1	74	13.8	88	15.9
65–74	77.0	27.5	94	31.3	80	25.7	84	25.9	84	24.5	81	22.5	105	27.9	101	25.8	88	21.8
75–84	70.5	39.5	94	51.6	87	47.4	88	47.5	82	43.6	68	35.5	67	34.1	72	35.4	62	29.2
≥85	30.0	50.5	53	80.8	57	83.2	58	82.0	45	61.8	38	50.9	46	59.2	43	53.7	43	51.8
Aggregated age groups (years)																		
<2	119.0	100.2	59	46.0	37	28.8	30	23.6	44	35.5	24	19.7	34	28.5	14	11.8	22	18.5
<5	154.5	53.4	100	32.6	65	20.7	48	15.1	58	18.4	40	12.8	55	17.8	24	7.8	46	15.1
5–64	208.0	6.1	356	10.3	246	7.1	274	7.9	220	6.3	252	7.2	216	6.1	207	5.7	241	6.5
≥65	177.5	34.2	241	44.0	224	39.8	230	39.7	211	35.0	187	29.9	218	33.5	216	32.0	193	27.6
Total	**540.0**	**12.8**	**697**	**16.2**	**535**	**12.3**	**552**	**12.6**	**489**	**11.1**	**479**	**10.8**	**489**	**10.8**	**447**	**9.7**	**480**	**10.2**

Note: Data presented from 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD. Where there are fewer than five cases in any category, a rate has not been calculated.

Table 14. Age-standardised rate per 100,000 population of invasive pneumococcal disease by ethnic group, age group and year, 2009–2016

Age group (years)	Ethnic group[a,b]															
	Māori								Pacific peoples							
	2009	2010	2011	2012	2013	2014	2015	2016	2009	2010	2011	2012	2013	2014	2015	2016
<2	87.8	63.4	45.7	43.9	35.1	52.0	19.6	25.3	66.0	49.4	58.1	85.3	-	53.1	-	-
<5	49.4	38.4	24.5	22.2	17.5	31.5	12.7	19.2	51.4	36.8	26.5	43.3	-	30.7	-	27.6
5–64	20.8	13.7	11.9	11.1	12.5	11.3	9.2	10.9	27.3	24.9	18.3	14.0	15.2	11.6	13.5	21.8
≥65	89.3	74.0	90.1	71.7	91.8	74.4	119.3	89.6	101.0	143.5	87.5	98.3	94.4	162.1	99.8	108.4
All ages[c]	**33.2**	**25.3**	**26.0**	**23.6**	**27.8**	**24.6**	**27.7**	**26.8**	**39.9**	**48.6**	**30.7**	**32.4**	**32.1**	**35.0**	**31.3**	**40.0**

Age group (years)	Ethnic group[a,b]															
	Asian								European or Other							
	2009	2010	2011	2012	2013	2014	2015	2016	2009	2010	2011	2012	2013	2014	2015	2016
<2	-	-	-	-	-	-	-	-	29.4	13.9	7.8	25.6	16.3	18.2	8.3	12.8
<5	13.8	18.9	16.0	-	-	-	-	-	24.6	9.9	7.3	12.9	11.8	11.9	7.0	11.5
5–64	3.0	1.8	1.6	1.1	2.7	3.8	1.5	2.1	7.4	4.6	6.8	4.9	5.7	4.4	4.6	4.5
≥65	23.8	-	-	25.1	-	-	25.5	21.5	38.4	36.0	35.8	31.0	24.0	25.9	24.0	21.0
All ages[c]	**7.4**	**5.5**	**4.2**	**5.8**	**4.3**	**6.1**	**5.7**	**6.5**	**12.4**	**9.2**	**10.3**	**8.8**	**8.3**	**7.8**	**7.3**	**7.0**

[a] Rates were not calculated for the Middle Eastern/Latin American/African (MELAA) ethnic group as there were less than five cases reported each year for this ethnic group (2010, 3 cases; 2011, 3 cases; 2012, 4 cases; 2013, 2 cases; 2014, 1 case; 2015, 1 case, 2016, 2 cases).

[b] Ethnicity was recorded for 680 (97.6%) in 2009, 532 (99.4%) cases in 2010, 540 (97.8%) cases in 2011, 476 (97.3%) cases in 2012, 464 (96.9%) cases in 2013, 465 (95.1%) in 2014, 433 (96.9%) in 2015 and 466 (97.1%) in 2016.

[c] Rates presented for all ages are direct-standardised to the age distribution of the total New Zealand population.

Note: 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 corresponding mid-year population estimates from Statistics New Zealand for 2010–2016. Ethnicity is prioritised in the following order: Māori, Pacific peoples, Asian, MELAA and European or Other ethnicity (including New Zealander). Where there are fewer than five cases in any category, a rate has not been calculated.

Table 15. Rate per 100,000 population of invasive pneumococcal disease by quintiles of the 2013 NZ Deprivation Index and year, 2009–2016

NZDep13 quintile[a]	2009		2010		2011		2012		2013		2014		2015		2016	
	Cases	Rate[b]	Cases	Rate[b]	Cases	Rate[b]	Cases	Rate[b]	Cases	Rate[b]	Cases	Rate[b]	Cases	Rate[b]	Cases	Rate[b]
1	65	7.4	51	5.8	57	6.5	64	7.3	42	5.8	42	4.6	63	6.9	54	5.9
2	81	9.5	65	7.6	66	7.7	70	8.1	70	7.6	77	8.6	60	6.7	55	6.2
3	109	13.0	83	9.9	95	11.3	77	9.2	83	9.9	69	7.9	81	9.2	81	9.2
4	154	18.6	103	12.4	121	14.6	96	11.6	98	12.4	103	11.9	81	9.3	96	11.1
5	234	28.1	199	23.9	178	21.4	158	19.0	157	23.9	180	20.5	146	16.7	172	19.6
Total[c]	**643**		**501**		**517**		**465**		**450**		**471**		**431**		**458**	

[a] Quintile of the 2013 New Zealand Deprivation Index (1 = least deprived and 5 = most deprived).

[b] Rate per 100,000 population, based on the 2013 census data from Statistics New Zealand. These rates should not be compared with disease rates used elsewhere in the report which have been calculated using the 2016 mid-year population estimates from Statistics New Zealand.

[c] Accurate New Zealand Deprivation Index (NZDep13) data was available for 643 (92.3%) cases in 2009, 501 (93.6%) cases in 2010, 517 (93.7%) cases in 2011, 465 (95.1%) cases in 2012, 450 (93.9%) cases in 2013, 471 (96.3%) cases in 2014, 431 (96.4%) cases in 2015 and 458 (95.4%) cases in 2016.

Table 16. Number of cases and rate per 100,000 population of invasive pneumococcal disease by clinical presentation and age group, 2016

Age group (years)	Meningitis		Empyema		Pneumonia		Bacteraemia without focus		Other	
	Cases[a]	Rate[b]	Cases[a]	Rate[b]	Cases[a]	Rate[b]	Cases[a]	Rate[b]	Cases[a]	Rate[b]
<1	5	8.4	1	-	4	-	2	-	1	-
1	3	-	2	-	5	8.4	4	-	0	-
2–4	1	-	4	-	15	8.1	7	3.8	4	-
5–14	5	0.8	2	-	5	0.8	5	0.8	5	0.8
15–64	23	0.7	4	-	158	5.1	41	1.3	26	0.8
≥65	7	1.0	5	0.7	150	21.5	40	5.7	22	3.1
Total[c]	**44**	**0.9**	**18**	**0.4**	**337**	**7.2**	**99**	**2.1**	**58**	**1.2**

[a] Number of cases with 'yes' recorded for each clinical presentation. Some cases reported having more than one clinical presentation. Any cases for which *S. pneumoniae* was identified in CSF were considered to be cases of pneumococcal meningitis.

[b] Where there are fewer than five cases, a rate has not been calculated.

[c] At least one clinical presentation was recorded for 474 (98.8%) cases notified in 2016.

Table 17. Case-fatality rates for invasive pneumococcal disease cases by age group, 2016

Age group (years)	Cases died[a]	Total reported[b]	Case-fatality rate[c] (%)
<1	1	9	11.1
1	0	13	0.0
2–4	0	24	0.0
5–14	0	15	0.0
15–64	10	222	4.5
≥65	11	183	6.0
Total	**22**	**466**	**4.7**

[a] Number of cases where IPD was recorded as the primary cause of death.

[b] Number of cases where information on whether they survived or died was recorded.

[c] Calculated on the basis of the number of cases for whom the information on outcomes was recorded. Information on whether the case survived or died was recorded for 466 (97.1%) of cases notified in 2016.

Table 18. Exposure to risk factors associated with invasive pneumococcal disease for cases aged <2 years, 2016

Risk factor	Cases[a]	Total reported[b]	%[c]
Premature (<37 weeks gestation)[d]	1	8	12.5
Smoking in the household	3	7	42.9
Attends childcare	2	5	40.0
Immunocompromised	1	20	5.0

[a] Number of cases with 'yes' recorded for each risk factor. Some cases reported exposure to more than one risk factor.

[b] Number of cases for which information was recorded for each risk factor.

[c] Percentage of cases with the risk for which the information was supplied.

[d] Cases aged <1 year only.

Note: No cases aged <2 years were reported as having anatomical or functional asplenia, chronic lung disease or cystic fibrosis, congenital or chromosomal abnormality, cochlear implants; or being a resident in a long-term or other chronic-care facility.

Table 19. Exposure to risk factors associated with invasive pneumococcal disease for cases aged <5 years, 2016

Risk factor	Cases[a]	Total reported[b]	%[c]
Premature (<37 weeks gestation)[d]	1	8	12.5
Smoking in the household	8	13	61.5
Attends childcare	2	7	28.6
Immunocompromised[e]	6	43	14.0
Chronic illness[f]	6	41	14.6
Chronic lung disease or cystic fibrosis	0	42	0.0
Congenital and chromosomal abnormality	3	40	7.5

[a] Number of cases with 'yes' recorded for each risk factor. Some cases reported exposure to more than one risk factor.
[b] Number of cases for which information was recorded for each risk factor.
[c] Percentage of cases with the risk for which the information was supplied.
[d] Cases aged <1 year only.
[e] Includes HIV/AIDS, lymphoma, organ transplant, multiple myeloma, nephrotic syndrome, chronic drug therapy, dysgammaglobulinaemia and sickle cell anaemia.
[f] Includes CSF leak, intracranial shunts, diabetes, cardiac disease, pulmonary disease, chronic liver disease, renal impairment and alcohol-related disease.
Note: No cases aged <5 years were reported as having anatomical or functional asplenia or cochlear implants; or being a resident in a long-term or other chronic-care facility.

Table 20. Exposure to risk factors associated with invasive pneumococcal disease for cases aged 5 years and over, 2016

Risk factor	Cases[a]	Total reported[b]	%[c]
Chronic illness[d]	249	401	62.1
Current smoker[e]	85	348	24.4
Immunocompromised[f]	90	395	22.8
Chronic lung disease or cystic fibrosis	58	395	14.7
Resident in long-term or other chronic-care facility[g]	25	395	6.3
Cochlear implants	0	367	0.0
Congenital or chromosomal abnormality	2	378	0.5
Anatomical or functional asplenia	6	379	1.6
Other risk factors	88	-	-

[a] Number of cases with 'yes' recorded for each risk factor. Some cases reported exposure to more than one risk factor.
[b] Number of cases for which information was recorded for each risk factor.
[c] Percentage of cases with the risk for which the information was supplied.
[d] Includes CSF leak, intracranial shunts, diabetes, cardiac disease, pulmonary disease, chronic liver disease, renal impairment and alcohol-related disease.
[e] Cases aged ≥15 years only.
[f] Includes HIV/AIDS, lymphoma, organ transplant, multiple myeloma, nephrotic syndrome, chronic drug therapy, dysgammaglobulinaemia and sickle cell anaemia.
[g] Among cases in the ≥75 years age group 19.6% (19 cases out of 97 for whom the information was supplied) were residents in a long-term or other chronic-care facility.

Table 21. Rate per 100,000 population of invasive pneumococcal disease by District Health Board, 2009–2016

District Health Board	Rate[a]							
	2009	2010	2011	2012	2013	2014	2015	2016
Northland	20.2	10.6	12.9	14.1	12.8	15.7	16.6	18.7
Waitemata	12.0	11.7	11.1	7.0	9.0	8.4	6.1	9.6
Auckland	11.6	10.1	11.5	11.4	8.3	11.4	7.3	10.6
Counties Manukau	19.0	21.9	15.4	15.3	12.1	13.6	13.2	15.9
Northern region	**14.8**	**14.2**	**12.7**	**11.3**	**10.1**	**11.5**	**9.6**	**12.6**
Waikato	22.7	12.8	12.4	11.2	10.6	11.2	10.0	7.5
Lakes	28.5	17.5	28.1	13.6	25.2	25.1	21.0	20.6
Bay of Plenty	24.0	15.6	13.6	16.8	16.7	13.8	13.1	14.6
Tairawhiti	19.4	-	10.7	-	10.6	14.9	14.8	20.9
Taranaki	18.3	9.0	9.8	12.4	7.9	12.2	6.0	-
Midland region	**22.9**	**13.2**	**14.2**	**12.8**	**13.5**	**13.8**	**11.8**	**10.9**
Hawke's Bay	22.6	15.3	16.5	13.3	15.1	10.0	8.7	8.0
Whanganui	19.0	14.3	9.5	9.6	16.1	16.1	11.2	7.9
MidCentral	10.3	10.8	11.3	6.5	10.1	12.3	8.1	5.2
Hutt Valley	21.2	14.7	11.9	8.4	7.7	9.1	11.1	6.2
Capital & Coast	10.5	8.0	6.5	9.9	9.5	9.8	9.0	8.5
Wairarapa	29.6	12.1	16.7	23.8	16.5	14.0	13.9	-
Nelson Marlborough	16.1	-	12.8	14.2	9.1	4.2	8.3	6.1
Central region	**16.0**	**10.4**	**11.2**	**10.8**	**10.9**	**9.9**	**9.3**	**7.1**
West Coast	-	-	-	-	18.2	-	-	-
Canterbury	10.9	8.2	13.4	8.2	7.9	7.8	7.8	8.2
South Canterbury	10.8	-	14.1	10.5	13.9	-	-	18.6
Southern	17.4	15.6	12.2	11.5	9.8	8.7	9.9	7.8
Southern region	**12.7**	**10.3**	**12.5**	**9.2**	**9.3**	**7.9**	**8.5**	8.4
Total	**16.2**	**12.3**	**12.6**	**11.1**	**10.8**	**10.8**	**9.7**	**10.2**

[a] Where there were fewer than five cases, a rate has not been calculated.

Table 22. Number of cases and rate per 100,000 population of invasive pneumococcal disease by serotype, serotypes covered by PCV7, PCV10 and PCV13, and age group, 2016

Serotype	<2 years		2–4 years		<5 years[a]		5–64 years		≥65 years[b]		Total	
	Cases	Rate[c]	Cases	Rate[c]	Cases	Rate[c]	Cases	Rate[c]	Cases	Rate[c]	Cases	Rate[c]
4	0	-	1	-	1	-	15	0.4	5	0.7	21	0.4
6B	0	-	0	-	0	-	1	-	0	-	1	-
9V	0	-	0	-	0	-	0	-	2	-	2	-
14	0	-	0	-	0	-	5	0.1	2	-	7	0.1
18C	0	-	0	-	0	-	1	-	1	-	2	-
19F	0	-	0	-	0	-	5	0.1	7	1.0	12	0.3
23F	0	-	0	-	0	-	0	-	2	-	2	-
PCV7	**0**	**-**	**1**	**-**	**1**	**-**	**27**	**0.7**	**19**	**2.7**	**47**	**1.0**
1	0	-	0	-	0	-	0	-	1	-	1	-
5	0	-	0	-	0	-	2	-	0	-	2	-
7F	1	-	0	-	1	-	26	0.7	6	0.9	33	0.7
19A	6	5.0	9	4.9	15	4.9	32	0.9	31	4.4	78	1.7
PCV10	**7**	**5.9**	**10**	**5.4**	**17**	**5.6**	**87**	**2.4**	**57**	**8.2**	**161**	**3.4**
3	2	-	2	-	4	-	13	0.4	10	1.4	27	0.6
6A	0	-	0	-	0	-	0	-	1	-	1	-
PCV13	**9**	**7.6**	**12**	**6.5**	**21**	**6.9**	**100**	**2.7**	**68**	**9.7**	**189**	**4.0**
6C	0	-	1	-	0	-	7	0.2	11	1.6	19	0.4
8	0	-	0	-	0	-	25	0.7	4	-	29	0.6
9N	2	-	0	-	2	-	4	-	8	1.1	14	0.3
10A	0	-	0	-	0	-	4	-	5	0.7	9	0.2
11A	0	-	0	-	0	-	4	-	4	-	8	0.2
12F	0	-	0	-	0	-	5	0.1	1	-	6	0.1
15A	0	-	1	-	1	-	6	0.2	7	1.0	14	0.3
15B	2	-	1	-	3	-	2	-	2	-	7	0.1
16F	0	-	0	-	0	-	7	0.2	4	-	11	0.2
17F	0	-	0	-	0	-	3	-	6	0.9	9	0.2
22F	1	-	2	-	3	-	16	0.4	20	2.9	39	0.8
23A	0	-	0	-	0	-	4	-	5	0.7	9	0.2
23B	0	-	0	-	0	-	9	0.2	9	1.3	18	0.4
31	0	-	0	-	0	-	4	-	3	-	7	0.1
33F	3	-	1	-	4	-	11	0.3	8	1.1	23	0.5
35B	0	-	1	-	1	-	5	0.1	3	-	9	0.2
38	0	-	1	-	1	-	1	-	4	-	6	0.1
Other[e]	2	-	3	-	3	-	16	0.4	10	1.4	29	0.6
Non-PCV[f]	**10**	**8.4**	**9**	**4.9**	**19**	**6.2**	**133**	**3.6**	**114**	**16.3**	**266**	**5.7**
Total[g]	**19**		**21**		**40**		**233**		**182**		**455**	

[a] Aggregated age group.

[b] Among the cases in the ≥65 years age group 69.2% were due to one of the serotypes included in PPV23. Vaccination with PPV23 is recommended for people in this age group.

[c] Rate per 100,000 population. Rates were not calculated where there were fewer than five cases.

[d] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[e] Includes non-PCV serotypes that accounted for less than five cases in 2016 and non-typeable serotypes

[f] The specific non-PCV serotypes listed are those that accounted for five or more cases of IPD in 2016.

[g] Total number of isolates from culture-positive cases referred to ESR for serotyping for each age group.

Table 23. Number and percentage of invasive pneumococcal disease cases by serotype for each age group, 2016

Serotype	<2 years		<5 years		5–64 years		≥65 years		All ages	
	Cases	%[a]	Cases	%[a]	Cases	%[a]	Cases	%[a]	Cases	%[a]
1	0	-	0	-	0	-	1	0.5	1	0.2
3	2	10.5	4	10.0	13	5.6	10	5.5	27	5.9
4	0	-	1	2.5	15	6.4	5	2.7	21	4.6
5	0	-	0	-	2	0.9	0	-	2	0.4
6A	0	-	0	-	0	-	1	0.5	1	0.2
6B	0	-	0	-	1	0.4	0	-	1	0.2
6C	0	-	1	2.5	7	3.0	11	6.0	19	4.2
6D	0	-	0	-	0	-	1	0.5	1	0.2
7C	0	-	0	-	2	0.9	0	-	2	0.4
7F	1	5.3	1	2.5	26	11.2	6	3.3	33	7.3
8	0	-	0	-	25	10.7	4	2.2	29	6.4
9N	2	10.5	2	5.0	4	1.7	8	4.4	14	3.1
9V	0	-	0	-	0	-	2	1.1	2	0.4
9 NT	0	-	0	-	0	-	1	0.5	1	0.2
10A	0	-	0	-	4	1.7	5	2.7	9	2.0
11A	0	-	0	-	4	1.7	4	2.2	8	1.8
12F	0	-	0	-	5	2.1	1	0.5	6	1.3
13	0	-	0	-	1	0.4	0	-	1	0.2
14	0	-	0	-	5	2.1	2	1.1	7	1.5
15A	0	-	1	2.5	6	2.6	7	3.8	14	3.1
15B	2	10.5	3	7.5	2	0.9	2	1.1	7	1.5
15C	0	-	1	2.5	0	-	1	0.5	2	0.4
16F	0	-	0	-	7	3.0	4	2.2	11	2.4
17F	0	-	0	-	3	1.3	6	3.3	9	2.0
18A	0	-	0	-	0	-	1	0.5	1	0.2
18C	0	-	0	-	1	0.4	1	0.5	2	0.4
19A	6	31.6	15	37.5	32	13.7	31	17.0	78	17.1
19F	0	-	0	-	5	2.1	7	3.8	12	2.6
20	0	-	0	-	0	-	1	0.5	1	0.2
21	0	-	0	-	1	0.4	2	1.1	3	0.7
22A	0	-	0	-	1	0.4	1	0.5	2	0.4
22F	1	5.3	3	7.5	16	6.9	20	11.0	39	8.6
23A	0	-	0	-	4	1.7	5	2.7	9	2.0
23B	0	-	0	-	9	3.9	9	4.9	18	4.0
23F	0	-	0	-	0	-	2	1.1	2	0.4
24 NT	1	5.3	1	2.5	0	-	0	-	1	0.2
31	0	-	0	-	4	1.7	3	1.6	7	1.5
33F	3	15.8	4	10.0	11	4.7	8	4.4	23	5.1
33 NT	0	-	0	-	2	0.9	1	0.5	3	0.7
34	0	-	0	-	4	1.7	0	-	4	0.9
35B	0	-	1	2.5	5	2.1	3	1.6	9	2.0
35F	0	-	0	-	2	0.9	0	-	2	0.4
38	0	-	1	2.5	1	0.4	4	2.2	6	1.3
Non-typable	1	5.3	1	2.5	3	1.3	1	0.5	5	1.1
Total[c]	**19**		**40**		**233**		**182**		**455**	

[a] Percentage of cases within the age group with the serotype.

[b] NT: not typable with the range of factorised antisera used at ESR.

[c] Total number of isolates from culture-positive cases referred to ESR for serotyping for each age group.

Table 24. Number of cases and rate per 100,000 population of invasive pneumococcal disease in the <2 years age group by serotype, and serotypes covered by PCV7, PCV10 and PCV13, 2006–2007 average, 2012–2016

Serotype	2006–2007 average		2012		2013		2014		2015		2016	
	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]
4	6.5	5.5	0	-	0	-	0	-	0	-	0	-
6B	18.0	15.2	0	-	0	-	0	-	1	-	0	-
9V	4.5	3.8	0	-	0	-	0	-	0	-	0	-
14	39.0	32.8	1	-	0	-	0	-	0	-	0	-
18C	6.0	5.1	0	-	0	-	1	-	0	-	0	-
19F	15.5	13.0	1	-	1	-	1	-	0	-	0	-
23F	9.0	7.6	0	-	0	-	0	-	0	-	0	-
PCV7	**98.5**	**82.9**	**2**	**-**	**1**	**-**	**2**	**-**	**1**	**-**	**0**	**-**
1	2.0	-	1	-	0	-	0	-	0	-	0	-
5	0.0	-	0	-	0	-	0	-	0	-	0	-
7F	0.5	-	2	-	1	-	0	-	0	-	1	-
19A[c]	6.0	5.1	13	10.5	7	5.8	12	10.0	2	-	6	5.0
PCV10[c]	**107.0**	**90.1**	**18**	**14.5**	**9**	**7.4**	**14**	**11.7**	**3**	**-**	**7**	**5.9**
3	1.0	-	2	-	3	-	7	5.9	0	-	2	-
6A/6C[d]	3.0	-	4	-	1	-	3	-	1	-	0	-
PCV13	**111.0**	**93.4**	**24**	**19.4**	**13**	**10.7**	**24**	**20.1**	**4**	**-**	**9**	**7.6**
8	0.0	-	2	-	2	-	2	-	1	-	0	-
9N	0.0	-	0	-	0	-	2	-	0	-	2	-
10A	0.0	-	3	-	1	-	0	-		-	0	-
11A	0.5	-	2	-	2	-	0	-	0	-	0	-
12F	0.0	-	0	-	0	-	0	-	0	-	0	-
15A	0.0	-	0	-	0	-	0	-	0	-	0	-
15B	0.5	-	4	-	0	-	0	-	1	-	2	-
16F	0.0	-	0	-	0	-	0	-	0	-	0	-
17F	0.0	-	1	-	0	-	0	-	0	-	0	-
22F	1.0	-	0	-	1	-	0	-	1	-	1	-
23A	0.0	-	0	-	0	-	1	-	2	-	0	-
23B	0.5	-	0	-	1	-	0	-	0	-	0	-
31	0.0	-	0	-	0	-	0	-	0	-	0	-
33F	0.5	-	0	-	1	-	2	-	2	-	3	-
35B	0.0	-	0	-	0	-	0	-	-	-	0	-
38	0.0	-	0	-	0	-	0	-	-	-	0	-
Other[e]	3.5	-	4	-	1	-	1	-	3	-	2	-
Non-PCV[f]	**6.5**	**5.5**	**16**	**12.9**	**10**	**8.2**	**8**	**6.7**	**10**	**8.4**	**10**	**8.4**

[a] Number of cases reported.

[b] Rate per 100,000 population. Rates were not calculated where there were fewer than five cases.

[c] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[d] Serotypes 6A and 6C were only distinguished from 2010 onwards; therefore they have been combined for this analysis.

[e] Includes non-PCV serotypes that accounted for less than five cases in 2016, non-typable serotypes and serotypes that could not be further typed at the time.

[f] The specific non-PCV serotypes listed are those that accounted for five or more cases in 2016.

Note: Data presented from 2012 onwards is based on IPD notifications and data for 2006/07 is from ESR's national laboratory-based surveillance of IPD.

Table 25. Number of cases and rate per 100,000 population of invasive pneumococcal disease in the <5 years age group by serotype, and serotypes covered by PCV7, PCV10 and PCV13, 2006–2007 average, 2012–2016

Serotype	2006–2007 average		2012		2013		2014		2015		2016	
	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]
4	8.0	2.8	0	-	0	-	1	-	1	-	1	-
6B	23.5	8.1	0	-	0	-	0	-	1	-	0	-
9V	7.0	2.4	1	-	0	-	0	-	0	-	0	-
14	47.5	16.4	2	-	0	-	1	-	0	-	0	-
18C	10.5	3.6	0	-	0	-	1	-	0	-	0	-
19F	19.0	6.6	1	-	1	-	1	-	0	-	0	-
23F	9.5	3.3	0	-	0	-	0	-	0	-	0	-
PCV7	**125.0**	**43.2**	**4**	**-**	**1**	**-**	**4**	**-**	**2**	**-**	**1**	**-**
1	2.5	-	1	-	2	-	1	-	0	-	0	-
5	0.0	-	0	-	0	-	0	-	0	-	0	-
7F	0.5	-	4	-	1	-	1	-	0	-	1	-
19A[c]	10.5	3.6	18	6.2	12	4.1	17	5.9	3	-	15	5.2
PCV10[c]	**138.5**	**47.8**	**27**	**8.6**	**16**	**5.1**	**23**	**7.4**	**5**	**1.6**	**17**	**5.6**
3	1.0	-	2	-	3	-	9	2.9	2	-	4	-
6A/6C[d]	4.5	1.6	4	-	1	-	4	-	2	-	1	-
PCV13	**144.0**	**49.7**	**33**	**10.5**	**20**	**6.4**	**36**	**11.7**	**9**	**2.9**	**22**	**7.2**
8	0.0	-	2	-	2	-	2	-	1	-	0	-
9N	0.0	-	0	-	0	-	2	-	0	-	2	-
10A	0.5	-	4		1		1		0		0	
11A	0.5	-	2	-	3	-	0	-	0	-	0	-
12F	0.0	-	0		0		0		0		0	-
15A	0.0	-	0	-	0	-	0	-	0	-	1	-
15B	1.0	-	6	1.9	1	-	1	-	3	-	3	-
16F	0.0	-	0	-	0	-	0	-	0	-	0	-
17F	0.5	-	1	-	1	-	0	-	0	-	0	-
22F	1.0	-	0	-	1	-	1	-	2	-	3	-
23A	0.5	-	0	-	0	-	1	-	2	-	0	-
23B	0.5	-	0	-	2	-	0	-	1	-	0	-
31	0.0	-	0	-	0	-	0	-	0	-	0	-
33F	1.0	-	0	-	1	-	2	-	2	-	4	-
35B	0.0	-	0	-	0	-	0	-	1	-	1	-
38	0.0	-	0	-	1	-	0	-	0	-	1	-
Other[e]	3.5	1.6	4	-	4	-	6	1.9	3	-	3	-
Non-PCV[f]	**9.0**	**3.3**	**19**	**6.0**	**17**	**5.4**	**16**	**5.2**	**15**	**4.9**	**18**	**5.9**

[a] Number of cases reported.

[b] Rate per 100,000 population. Rates were not calculated where there were fewer than five cases.

[c] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[d] Serotypes 6A and 6C were only distinguished from 2010 onwards; therefore they have been combined for this analysis.

[e] Includes non-PCV serotype that accounted for less than five cases in 2016, non-typable serotypes and serotypes that could not be further typed at the time.

[f] The specific non-PCV serotypes listed are those that accounted for five or more cases in 2016.

Note: Data presented from 2012 onwards is based on IPD notifications and data for 2006/07 is from ESR's national laboratory-based surveillance of IPD.

Table 26. Number of cases and rate per 100,000 population of invasive pneumococcal disease in the 5–64 years age group by serotype, and serotypes covered by PCV7, PCV10 and PCV13, 2006–2007 average, 2012–2016

Serotype	2006–2007 average		2012		2013		2014		2015		2016	
	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]
4	38.0	1.1	25	0.7	23	0.7	13	0.4	9	0.2	15	0.4
6B	11.5	0.3	3	-	3	-	1	-	0	-	1	-
9V	11.0	0.3	5	0.1	8	0.2	5	0.1	3	-	0	-
14	31.0	0.9	11	0.3	3	-	1	-	0	-	5	0.1
18C	5.5	0.2	5	0.1	10	0.3	3	-	1	-	1	-
19F	12.0	0.4	13	0.4	7	0.2	2	-	14	0.4	5	0.1
23F	12.0	0.4	5	0.1	3	-	1	-	1	-	0	-
PCV7	**121.0**	**3.6**	**67**	**1.9**	**57**	**1.6**	**26**	**0.7**	**28**	**0.8**	**27**	**0.7**
1	19.0	0.6	7	0.2	1	-	0	-	0	-	0	-
5	0.0	-	0	-	0	-	0	-	0	-	2	-
7F	6.0	0.2	18	0.5	48	1.4	35	1.0	28	0.8	26	0.7
19A[c]	10.0	0.3	30	0.9	36	1.0	40	1.1	40	1.1	32	0.9
PCV10[c]	**156.0**	**4.6**	**122**	**3.5**	**142**	**4.1**	**101**	**2.8**	**96**	**2.7**	**87**	**2.4**
3	8.5	0.3	9	0.3	9	0.3	18	0.5	15	0.4	13	0.4
6A/6C[d]	5.0	0.1	6	0.2	11	0.3	10	0.3	14	0.4	7	0.2
PCV13	**169.5**	**5.0**	**137**	**3.9**	**162**	**4.6**	**129**	**3.8**	**125**	**3.5**	**107**	**2.9**
8	12.0	0.4	11	0.3	10	0.3	12	0.3	12	0.3	25	0.7
9N	3.5	-	5	0.1	2	-	5	0.1	5	0.1	4	-
10A	3.0	-	2	-	3	-	2	-	3	-	4	-
11A	3.5	-	5	0.1	7	0.2	2	-	1	-	4	-
12F	0.5	-	1	-	3	-	1	-	1	-	5	0.1
15A	0.0	-	0	-	0	-	1	-	2	-	6	0.2
15B	0.5	-	2	-	2	-	2	-	4	-	2	-
16F	0.0	-	0	-	0	-	0	-	2	-	7	0.2
17F	1.0	-	2	-	2	-	3	-	1	-	3	-
22F	5.0	0.1	19	0.5	24	0.7	17	0.5	15	0.4	16	0.4
23A	0.5	-	4	-	0	-	5	0.1	4	-	4	-
23B	0.5	-	5	0.1	1	-	6	0.2	3	-	9	0.2
31	0.0	-	0	-	1	-	2	-	2	-	4	-
33F	0.0	-	1	-	5	0.1	3	-	4	-	11	0.3
35B	0.0	-	0	-	0	-	0	-	2	-	5	0.1
38	0.0	-	0	-	0	-	1	-	2	-	1	-
Other[e]	8.0	0.4	9	0.3	16	0.5	19	0.8	8	0.2	16	0.4
Non-PCV[f]	**38.0**	**1.1**	**66**	**1.9**	**76**	**2.2**	**81**	**2.3**	**73**	**2.0**	**126**	**3.4**

[a] Number of cases reported.

[b] Rate per 100,000 population. Rates were not calculated where there were fewer than five cases.

[c] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A.

[d] Serotypes 6A and 6C were only distinguished from 2010 onwards; therefore they have been combined for this analysis.

[e] Includes non-PCV serotypes that accounted for less than five cases in 2016, non-typable serotypes and serotypes that could not be further typed at the time.

[f] The specific non-PCV serotypes listed are those that accounted for five or more cases in 2016.

Note: Data presented from 2012 onwards is based on IPD notifications and data for 2006/07 is from ESR's national laboratory-based surveillance of IPD.

Table 27. Number of cases and rate per 100,000 population of invasive pneumococcal disease in the 65 years and over age group by serotype, and serotypes covered by PCV7, PCV10 and PCV13, 2006–2007 average, 2012–2016

Serotype	2006–2007 average		2012		2013		2014		2015		2016	
	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]
4	19.5	3.8	22	3.6	9	1.4	10	1.5	7	1.0	5	0.7
6B	11.0	2.1	5	0.8	4	-	1	-	1	-	0	-
9V	14.5	2.8	8	1.3	3	-	2	-	1	-	2	-
14	35.5	6.8	5	0.8	4	-	2	-	3	-	2	-
18C	3.0	-	4	-	6	1.0	5	0.8	1	-	1	-
19F	16.5	3.2	11	1.8	5	0.8	7	1.1	5	0.7	7	1.0
23F	15.0	2.9	4	-	3	-	1	-	5	0.7	2	-
PCV7	**115.0**	**22.2**	**59**	**9.8**	**34**	**5.4**	**28**	**4.3**	**23**	**3.4**	**19**	**2.7**
1	3.5	-	0	-	0	-	0	-	1	-	1	-
5	0.0	-	0	-	0	-	0	-	0	-	0	-
7F	3.5	-	15	2.5	20	3.2	18	2.8	10	1.5	6	0.9
19A[c]	8.0	1.5	32	5.3	28	4.5	30	4.6	47	7.0	31	4.4
PCV10[c]	**130.0**	**25.1**	**106**	**17.6**	**82**	**13.1**	**75**	**11.5**	**81**	**12.0**	**57**	**8.2**
3	12.5	2.4	14	2.3	11	1.8	15	2.3	16	2.4	10	1.4
6A/6C[d]	2.5	-	12	2.0	12	1.9	13	2.0	11	1.6	12	1.7
PCV13	**145.0**	**28.0**	**132**	**21.9**	**105**	**16.8**	**104**	**16.0**	**108**	**16.0**	**79**	**11.3**
8	3.5	-	5	0.8	5	0.8	7	1.1	5	0.7	4	-
9N	4.0	-	3	-	10	1.6	10	1.5	4	-	8	1.1
10A	2.0	-	4	-	2	-	4	-	1	-	5	0.7
11A	3.5	-	7	1.2	1	-	10	1.5	4	-	4	-
12F	0.5	-	1	-	0	-	1	-	3	-	1	-
15A	0.0	-	0	-	0	-	0	-	4	-	7	1.0
15B	1.0	-	2	-	5	0.8	4	-	6	0.9	2	-
16F	0.0	-	0	-	0	-	0	-	3	-	4	-
17F	1.0	-	0	-	3	-	1	-	2	-	6	0.9
22F	4.5	0.9	21	3.5	16	2.6	21	3.2	23	3.4	20	2.9
23A	1.0	-	1	-	6	1.0	5	0.8	10	1.5	5	0.7
23B	0.5	-	2	-	3	-	4	-	8	1.2	9	1.3
31	0.0	-	1	-	1	-	3	-	3	-	3	-
33F	1.5	-	8	1.3	5	0.8	4	-	8	1.2	8	1.1
35B	0.0	-	0	-	0	-	0	-	1	-	3	-
38	0.0	-	2	-	2	-	2	-	1	-	4	-
Other[e]	9.0	1.7	15	2.5	15	2.4	29	4.5	14	2.1	10	1.4
Non-PCV[f]	**32.0**	**6.2**	**72**	**11.9**	**74**	**11.8**	**105**	**16.1**	**100**	**14.8**	**103**	**14.7**

[a] Number of cases reported.

[b] Rate per 100,000 population. Rates were not calculated where there were fewer than five cases.

[c] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[d] Serotypes 6A and 6C were only distinguished from 2010 onwards; therefore they have been combined for this analysis.

[e] Includes non-PCV serotypes that accounted for less than five cases in 2016, non-typable serotypes and serotypes that could not be further typed at the time.

[f] The specific non-PCV serotypes listed are those that accounted for five or more cases in 2016.

Note: Data presented from 2012 onwards is based on IPD notifications and data for 2006/07 is from ESR's national laboratory-based surveillance of IPD.

Table 28. Number of cases and rate per 100,000 population of invasive pneumococcal disease by serotype, and serotypes covered by PCV7, PCV10 and PCV13, all ages, 2006–2007 average, 2012–2016

Serotype	2006–2007 average		2012		2013		2014		2015		2016	
	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]	No[a]	Rate[b]
4	65.5	1.6	47	1.1	32	0.7	24	0.5	17	0.4	21	0.4
6B	46.0	1.1	8	0.2	7	0.2	2	-	2	-	1	-
9V	32.5	0.8	14	0.3	11	0.2	7	0.2	4	-	2	-
14	115.0	2.7	18	0.4	7	0.2	4	-	3	-	7	0.1
18C	19.0	0.5	9	0.2	16	0.4	9	0.2	2	-	2	-
19F	47.5	1.1	25	0.6	13	0.3	10	0.2	19	0.4	12	0.3
23F	36.5	0.9	9	0.2	6	0.1	2	-	6	0.1	2	-
PCV7	**361.0**	**8.6**	**131**	**3.0**	**92**	**2.1**	**58**	**1.3**	**53**	**1.2**	**47**	**1.0**
1	25.0	0.6	8	0.2	3	-	1	-	1	-	1	-
5	0.0	-	0	-	0	-	0	-	0	-	2	-
7F	10.0	0.2	37	0.8	69	1.6	54	1.2	38	0.8	33	0.7
19A[c]	28.5	0.7	80	1.8	76	1.7	87	1.9	90	2.0	78	1.7
PCV10[c]	**424.5**	**10.1**	**255**	**5.8**	**240**	**5.4**	**199**	**4.4**	**182**	**4.0**	**161**	**3.4**
3	22.0	0.5	25	0.6	23	0.5	42	0.9	33	0.7	27	0.6
6A/6C[d]	12.0	0.3	22	0.5	24	0.5	27	0.6	27	0.6	20	0.4
PCV13	**458.5**	**10.9**	**303**	**6.9**	**287**	**6.5**	**268**	**5.9**	**242**	**5.3**	**208**	**4.4**
8	15.5	0.4	18	0.4	17	0.4	21	0.5	18	0.4	29	0.6
9N	8.0	0.2	8	0.2	12	0.3	17	0.4	9	0.2	14	0.3
10A	6.0	-	10	0.2	6	0.1	7	0.2	4	-	9	0.2
11A	7.5	0.2	13	0.3	11	0.2	12	0.3	5	0.1	8	0.2
12F	1.0	-	2	-	3	-	2	-	4	-	6	0.1
15A	0.0	-	0	-	0	-	1	-	6	0.1	14	0.3
15B	2.5	-	10	0.2	8	0.2	7	0.2	13	0.3	7	0.1
16F	0.0	-	0	-	0	-	0	-	5	0.1	11	0.2
17F	2.5	-	3	-	6	-	4	-	3	-	9	0.2
22F	10.5	0.2	40	0.9	41	0.9	39	0.9	40	0.9	39	0.8
23A	2.0	-	6	0.1	6	0.1	11	0.2	16	0.3	9	0.2
23B	1.5	-	7	0.2	6	0.1	10	0.2	12	0.3	18	0.4
31	0.0	-	1	-	2	-	5	0.1	5	0.1	7	0.1
33F	2.5	-	9	0.2	11	0.2	9	0.2	14	0.3	23	0.5
35B	0.0	-	0	-	0	-	0	-	4	-	9	0.2
38	0.0	-	2	-	3	-	3	-	3	-	6	0.1
Other[e]	29.5	0.7	28	0.6	35	0.8	55	1.2	27	0.6	29	0.6
Non-PCV[f]	**80.0**	**1.9**	**157**	**3.6**	**167**	**3.8**	**203**	**4.5**	**188**	**4.1**	**247**	**5.3**

[a] Number of cases reported.

[b] Rate per 100,000 population. Rates were not calculated where there were fewer than five cases.

[c] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[d] Serotypes 6A and 6C were only distinguished from 2010 onwards; therefore they have been combined for this analysis.

[e] Includes non-PCV serotypes that accounted for less than five cases in 2016, non-typable serotypes and serotypes that could not be further typed at the time.

[f] The specific non-PCV serotypes listed are those that accounted for five or more cases in 2016.

Note: Data presented from 2012 onwards is based on IPD notifications and data for 2006/07 is from ESR's national laboratory-based surveillance of IPD.

Table 29. Serotype 19A invasive pneumococcal disease case numbers, proportions and rates per 100,000 population, by age group, 2004–2016

Year	<2 years			<5 years			5–64 years			≥65 years			All ages		
	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]
2004	8	6.3	7.0	10	6.2	3.5	5	2.6	0.2	8	4.2	1.7	23	4.2	0.6
2005	6	5.3	5.2	8	5.3	2.8	10	5.6	0.3	9	5.5	1.8	27	5.5	0.7
2006	5	4.2	4.3	10	6.6	3.5	13	6.4	0.4	4	2.4	-	27	5.2	0.6
2007	7	6.0	5.8	11	7.1	3.8	7	3.3	0.2	12	6.5	2.3	30	5.4	0.7
2008	5	6.4	4.0	7	6.3	2.3	22	7.6	0.6	11	4.8	2.1	40	6.3	0.9
2009	8	14.5	6.2	12	12.9	3.9	16	4.7	0.5	9	3.9	1.6	37	5.6	0.9
2010	7	19.4	5.4	10	15.9	3.2	23	9.8	0.7	22	10.1	3.9	55	10.7	1.3
2011	8	28.6	6.3	13	28.9	4.1	26	10.0	0.7	24	10.5	4.1	63	11.8	1.4
2012	13	32.5	10.5	18	34.6	5.7	30	14.7	0.9	32	15.7	5.3	80	17.4	1.8
2013	7	30.4	5.8	12	32.4	3.8	36	15.1	1.0	28	15.6	4.5	76	16.7	1.7
2014	12	37.5	10.0	17	32.7	5.5	40	19.0	1.1	30	14.4	4.6	87	18.4	1.9
2015	2	14.3	-	3	12.5	-	40	20.2	1.1	47	22.6	7.0	90	20.9	2.0
2016	6	31.6	5.0	15	37.5	4.9	32	13.7	0.9	31	17.0	4.4	78	17.1	1.7

[a] Number of cases due to serotype 19A.

[b] Percentage of cases within the age group due to serotype 19A.

[c] Rate per 100,000 population for IPD due to serotype 19A. Rates were not calculated where there were fewer than five cases.

Note: Data presented from 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD.

Table 30. Serotype 7F invasive pneumococcal disease case numbers, proportions and rates per 100,000 population, by age group, 2004–2016

Year	<2 years			<5 years			5–64 years			≥65 years			All ages		
	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]	Cases[a]	%[b]	Rate[c]
2004	2	1.6	-	3	1.9	-	12	6.2	0.4	1	0.5	-	18	3.3	0.4
2005	2	1.8	-	3	2.0	-	4	2.3	-	2	1.2	-	11	2.2	0.3
2006	0	0.0	-	0	0.0	-	8	4.0	0.2	3	1.8	-	11	2.1	0.3
2007	1	0.9	-	1	0.6	-	4	1.9	-	4	2.2	-	9	1.6	0.2
2008	0	0.0	-	0	0.0	-	12	4.1	0.4	2	0.9	-	14	2.2	0.3
2009	1	1.8	-	1	1.1	-	13	3.8	0.4	4	1.7	-	18	2.7	0.4
2010	2	5.6	-	2	3.2	-	4	1.7	-	3	1.4	-	9	1.8	0.2
2011	2	7.1	-	4	8.9	-	11	4.2	0.3	1	0.4	-	16	3.0	0.4
2012	2	5.0	-	4	7.7	-	18	8.8	0.5	15	7.4	2.5	37	8.0	0.8
2013	1	4.3	-	1	2.7	-	48	20.2	1.4	20	11.2	3.1	69	15.2	1.5
2014	0	0.0	-	1	1.9	-	35	16.6	1.0	18	8.6	2.8	54	11.4	1.2
2015	0	0.0	-	0	0.0	-	28	14.1	0.8	10	4.8	1.5	38	8.8	0.8
2016	1	5.3	-	1	2.5	-	26	11.2	0.7	6	3.3	0.9	33	7.3	0.7

[a] Number of cases due to serotype 7F.

[b] Percentage of cases within the age group due to serotype 7F.

[c] Rate per 100,000 population for IPD due to serotype 7F. Rates were not calculated where there were fewer than five cases.

Note: Data presented from 2009 onwards is based on IPD notifications and data prior to 2009 is from ESR's national laboratory-based surveillance of IPD.

Table 31. Penicillin and cefotaxime MIC distribution among isolates from invasive pneumococcal disease cases, 2016

Antibiotic	Percent of isolates with an MIC (mg/L) of:[a]										
	0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8
Penicillin	0.7	46.6	26.2	3.1	4.6	9.7	4.0	2.6	1.3	1.1	0.2
Cefotaxime	6.8	60.9	6.2	4.4	10.8	4.0	4.2	1.5	0.4	0.4	0.4

[a] Shaded cells represent MICs that are categorised as penicillin resistant (meningitis breakpoints) or cefotaxime non-susceptible (intermediate and resistant), based on the EUCAST breakpoints: penicillin resistant, MIC ≥0.12 mg/L; cefotaxime intermediate, MIC 1-2 mg/L; and cefotaxime resistant, MIC ≥4 mg/L [21].

Table 32. Trends in penicillin susceptibility, cefotaxime susceptibility and multidrug resistance among isolates from invasive pneumococcal disease cases, 2007–2016

Year	Number of isolates	Penicillin								Cefotaxime						% MDR[h]
		Meningitis[a,b]		Non-meningitis[a,c]			Oral[a,d]			Meningitis (CLSI)[a,e]			All infections (EUCAST)[a,f] Non-meningitis (CLSI)[a,g]			
		%S	%R	%S	%I	%R	%S	%I	%R	%S	%I	%R	%S	%I	%R	
2007	555	77.7	22.3	99.1	0.7	0.2	77.7	16.0	6.3	86.0	11.4	2.7	97.3	1.1	1.6	6.1
2008	630	77.9	22.1	99.5	0.5	0.0	77.9	14.6	7.5	84.9	10.0	5.1	94.9	3.0	2.1	5.9
2009	665	82.3	17.7	99.7	0.3	0.0	82.3	12.3	5.4	91.1	6.9	2.0	98.1	1.4	0.6	5.3
2010	514	81.9	18.1	99.0	1.0	0.0	81.9	12.1	6.0	91.8	6.2	1.9	98.1	0.4	1.6	5.4
2011	533	85.9	14.1	99.1	0.8	0.2	85.9	9.4	4.7	93.4	3.6	3.0	97.0	1.1	1.9	5.8
2012	459	82.8	17.2	98.0	1.3	0.7	82.8	9.4	7.8	92.4	3.5	4.1	95.9	2.8	1.3	6.3
2013	454	83.9	16.1	98.5	1.3	0.2	83.9	10.1	6.0	91.9	4.4	3.7	96.3	3.3	0.4	4.0
2014	472	82.4	17.6	98.1	1.7	0.2	82.4	13.1	4.4	93.4	2.8	3.8	96.2	2.8	1.1	4.2
2015	430	78.1	21.9	97.9	1.6	0.5	78.1	17.4	4.4	93.5	4.0	2.6	97.4	1.6	0.9	4.7
2016	455	76.5	23.5	76.5	22.2	1.3	-	-	-	-	-	-	97.1	2.0	0.9	3.7

[a] The data for 2007–2015 is based on testing and interpretation according to CLSI methods and breakpoints. The data for 2016 is based on testing and interpretation according to EUCAST methods and breakpoints.

[b] EUCAST and CLSI penicillin meningitis breakpoints: susceptible (S), MIC ≤0.06 mg/L; resistant (R), MIC ≥0.12 mg/L [21].

[c] Penicillin non-meningitis breakpoints. EUCAST: susceptible (S), MIC ≤0.06 mg/L; intermediate (I), MIC 0.12-2 mg/L; resistant (R), MIC ≥4 mg/L [18]. CLSI (parenteral treatment): susceptible (S), MIC ≤2 mg/L; intermediate (I), MIC 4 mg/L; resistant (R), MIC ≥8 mg/L [21].

[d] CLSI penicillin non-meningitis (oral treatment) breakpoints: susceptible (S), MIC ≤0.06 mg/L; intermediate (I), MIC 0.12-1 mg/L; resistant (R), MIC ≥2 mg/L [21]. Note there are no EUCAST breakpoints specifically for oral penicillin treatment [18].

[e] CLSI cefotaxime meningitis breakpoints: susceptible (S), MIC ≤0.5 mg/L; intermediate (I), MIC 1 mg/L; resistant (R), MIC ≥2 mg/L [21]. Note there are no EUCAST cefotaxime breakpoints specifically for meningitis [18].

[f] EUCAST cefotaxime breakpoints: susceptible (S), MIC ≤0.5 mg/L; intermediate (I), MIC 1-2 mg/L; resistant (R), MIC ≥4 mg/L [21]. Note the EUCAST cefotaxime breakpoints are not infection specific, but they have been tabulated with the CLSI non-meningitis breakpoints as the resistance category is the same (ie, ≥4 mg/L).

[g] CLSI cefotaxime non-meningitis breakpoints: susceptible (S), MIC ≤1 mg/L; intermediate (I), MIC 2 mg/L; resistant (R), MIC ≥4 mg/L [21].

[h] Multidrug resistant − resistant to penicillin (meningitis breakpoints) and ≥3 additional antibiotics.

Table 33. Trends in resistance to non-β-lactam antibiotics among isolates from invasive pneumococcal disease cases, 2007–2016

Year[a]	Number of isolates	Chloramphenicol		Clindamycin[a]			Co-trimoxazole			Erythromycin			Tetracycline		
		%S[b]	%R[b]	%S[b]	%I[b]	%R[b,c]	%S[b]	%I[b]	%R[b]	%S[b]	%I[b]	%R[b]	%S[b]	%I[b]	%R[b]
2007	555	97.7	2.3	93.7	0.0	6.3	63.2	1.8	35.0	86.0	0.4	13.7	90.8	0.7	8.5
2008	630	97.6	2.4	94.6	0.0	5.4	67.6	2.2	30.2	87.8	0.3	11.9	91.9	0.5	7.6
2009	665	98.8	1.2	95.3	0.2	4.5	72.6	2.1	25.3	90.2	0.2	9.6	92.5	0.3	7.2
2010	514	98.1	2.0	94.7	0.0	5.3	73.5	2.1	24.3	91.1	0.0	9.0	91.6	0.8	7.6
2011	533	99.1	0.9	93.4	0.0	6.6	78.4	0.8	20.8	88.7	0.0	11.3	90.6	0.6	8.8
2012	459	99.6	0.4	94.1	0.0	5.9	77.3	1.3	21.4	91.3	0.0	8.7	91.9	0.0	8.1
2013	454	99.1	0.9	96.3	0.0	3.7	75.6	2.9	21.6	94.3	0.0	5.7	92.5	0.0	7.5
2014	472	99.4	0.6	94.3	0.0	5.9	79.0	1.9	19.1	92.2	0.0	7.8	92.6	0.0	7.4
2015	430	98.1	1.9	93.0	0.0	7.0	75.1	4.7	20.2	89.3	0.2	10.5	90.0	0.0	10.0
2016	455	99.1	0.9	92.7	0.0	7.3	74.3	4.2	21.5	88.4	0.0	11.6	91.6	0.2	8.1

[a] The data for 2007-2015 is based on testing and interpretation according to CLSI methods and breakpoints. The data for 2016 is based on testing and interpretation according to EUCAST methods and breakpoints.

[b] S: susceptible; I: intermediate; R: resistant.

[c] Includes isolates with inducible clindamycin resistance.

Note: All isolates were susceptible to vancomycin and moxifloxacin. Rifampicin susceptibility tested since 2010, and all isolates have been susceptible.

Table 34. Penicillin and cefotaxime resistance among isolates from invasive pneumococcal disease cases by region and District Health Board, 2016

Region / District Health Board	Number of isolates	Penicillin	Cefotaxime	
		% resistant[a] MIC ≥0.12 mg/L	% intermediate MIC 1-2 mg/L	% resistant MIC ≥4 mg/L
Northland	29	10.3	0.0	0.0
Waitemata	52	36.5	1.9	3.8
Auckland	54	40.7	5.6	1.9
Counties Manukau	78	24.4	0.0	0.0
Northland region	**213**	**29.6**	**1.9**	**1.4**
Waikato	30	16.7	3.3	0.0
Lakes	22	27.3	0.0	0.0
Bay of Plenty	33	27.3	3.0	0.0
Tairawhiti	5	20.0	0.0	0.0
Taranaki	3	33.3	33.3	0.0
Midland region	**93**	**23.7**	**3.3**	**0.0**
Hawke's Bay	13	15.4	0.0	0.0
Whanganui	5	0.0	0.0	0.0
MidCentral	8	12.5	0.0	0.0
Hutt Valley	9	11.1	0.0	11.1
Capital & Coast	24	16.7	0.0	0.0
Wairarapa	3	0.0	0.0	0.0
Nelson Marlborough	9	11.1	0.0	0.0
Central region	**71**	**12.7**	**0.0**	**1.4**
West Coast	0	-	-	-
Canterbury	43	14.0	2.3	0.0
South Canterbury	11	9.1	0.0	0.0
Southern	24	25.0	4.2	0.0
Southern region	**78**	**16.7**	**2.6**	**0.0**
Total	**455**	**23.5**	**2.0**	**0.9**

[a] EUCAST meningitis breakpoints; no intermediate category [21].

Table 35. Serotypes among penicillin-resistant, cefotaxime-resistant and multidrug-resistant isolates from invasive pneumococcal disease cases, 2016

Serotype	Penicillin		Cefotaxime				% MDR[b]	
	Resistant[a] MIC ≥0.12 mg/L		Intermediate MIC 1-2mg/L		Resistant MIC ≥4 mg/L			
	Number	%[c]	Number	%[c]	Number	%[c]	Number	%[c]
4	0	-	0	-	0	-	0	-
6B	1	0.9	0	-	0	-	1	5.9
9V	2	1.9	0	-	0	-	0	-
14	3	2.8	2	22.2	0	-	0	-
18C	1	0.9	0	-	0	-	1	5.9
19F	9	8.4	3	33.3	4	100.0	8	47.1
23F	1	0.9	0	-	0	-	0	-
PCV7 serotypes	**17**	**15.9**	**5**	**55.6**	**4**	**100.0**	**10**	**58.8**
1	0	-	0	-	0	-	0	-
5	0	-	0	-	0	-	0	-
7F	0	-	0	-	0	-	0	-
19A[d]	52	48.6	4	44.4	0	-	4	23.5
PCV10 serotypes[d]	**69**	**64.5**	**9**	**100.0**	**4**	**100.0**	**14**	**100.00**
3	1	0.9	0	-	0	-	0	-
6A	0	-	0	-	0	-	0	-
PCV13 serotypes	**70**	**65.4**	**9**	**100.0**	**4**	**100.0**	**14**	**82.4**
6C	3	2.8	0	-	0	-	0	-
15A	10	9.3	0	-	0	-	1	5.9
15B	5	4.7	0	-	0	-	2	11.8
23A	1	0.9	0	-	0	-	0	-
23B	6	5.6	0	-	0	-	0	-
33 NT[e]	2	1.9	0	-	0	-	0	-
34	3	2.8	0	-	0	-	0	-
35B	6	5.6	0	-	0	-	0	-
Non-typable[e]	1	0.9	0	-	0	-	0	-
Non-PCV serotypes	**37**	**34.6**	**0**	**-**	**0**	**-**	**3**	**17.6**
Total	**107**		**9**		**4**		**17**	

[a] EUCAST meningitis breakpoints; no intermediate category.[21]

[b] Multidrug resistant − resistant to penicillin (EUCAST meningitis breakpoints) and ≥3 additional antibiotics.[21]

[c] Percentage of the intermediate or resistant isolates.

[d] Serotype 19A is included with the PCV10 serotypes because serotype 19F elicits cross-reactive antibodies against serotype 19A

[e] NT: not typable with the range of factorised antisera used at ESR.

Table 36. Trends in penicillin resistance, cefotaxime resistance and multidrug resistance among serotype 19A isolates from invasive pneumococcal disease cases, 2007–2016

Year	Number of serotype 19A isolates	Penicillin resistant[a,b]		Cefotaxime resistant[a,c]		% MDR[d]	
		No[e]	% (95% CI)[f]	No[e]	% (95% CI)[f]	No[e]	% (95% CI)[f]
2007	30	3	10.0 (2.1–26.5)	0	0.0 (0.0–11.6)	1	3.3 (0.1-17.2)
2008	40	10	25.0 (12.7–41.2)	1	2.5 (0.1–13.2)	3	7.5 (1.6-20.4)
2009	37	3	8.1 (1.7–21.9)	0	0.0 (0.0–9.5)	0	0.0 (0.0-9.5)
2010	54	10	18.5 (9.3–31.4)	0	0.0 (0.0–6.6)	4	7.4 (2.1-17.9)
2011	63	16	25.4 (15.3–37.9)	0	0.0 (0.0–5.7)	2	3.2 (0.4-11.0)
2012	80	31	38.8 (28.1–50.3)	0	0.0 (0.0–4.5)	12	15.0 (8.0-24.8)
2013	76	36	47.4 (35.8–59.2)	0	0.0 (0.0–4.7)	11	14.5 (7.5-24.4)
2014	87	43	49.4 (38.5–60.4)	1	1.1 (0.0-6.2)	10	11.5 (5.7-20.1)
2015	90	49	54.4 (43.–65.0)	0	0.0 (0.0–4.0)	6	6.7 (2.5-13.9)
2016	78	52	66.7 (55.–76.9)	0	0.0 (0.0–4.6)	4	5.1 (1.4-12.6)

[a] The data for 2007–2015 is based on testing and interpretation according to CLSI methods and breakpoints. The data for 2016 is based on testing and interpretation according to EUCAST methods and breakpoints.

[b] EUCAST and CLSI penicillin meningitis resistance breakpoint, MIC ≥0.12 mg/L. [21]

[c] CLSI cefotaxime non-meningitis resistance breakpoint, MIC ≥4 mg/L [21]. EUCAST cefotaxime resistance breakpoint, MIC ≥4 mg/L.[21]

[d] Multidrug resistant − resistant to penicillin (meningitis breakpoints) and ≥3 additional antibiotics.[21]

[e] Number of resistant isolates.

[f] 95% CI: 95% confidence interval.

INSTITUTE OF ENVIRONMENTAL SCIENCE AND RESEARCH LIMITED

Kenepuru Science Centre
34 Kenepuru Drive, Kenepuru, Porirua 5022
PO Box 50348, Porirua 5240
New Zealand
T: +64 4 914 0700 **F:** +64 4 914 0770

Mt Albert Science Centre
120 Mt Albert Road, Sandringham, Auckland 1025
Private Bag 92021, Auckland 1142
New Zealand
T: +64 9 815 3670 **F:** +64 9 849 6046

NCBID – Wallaceville
66 Ward Street, Wallaceville, Upper Hutt 5018
PO Box 40158, Upper Hutt 5140
New Zealand
T: +64 4 529 0600 **F:** +64 4 529 0601

Christchurch Science Centre
27 Creyke Road, Ilam, Christchurch 8041
PO Box 29181, Christchurch 8540
New Zealand
T: +64 3 351 6019 **F:** +64 3 351 0010

www.esr.cri.nz