Science for Communities
He Pūtaiao, He Tāngata

INVASIVE PNEUMOCOCCAL DISEASE IN NEW ZEALAND, 2021

Prepared as part of a Ministry of Health contract for scientific services

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- Staff in the ESR Invasive Pathogens Laboratory for serotyping data.
- Staff in the ESR Antibiotic Reference Laboratory for antimicrobial susceptibility data.

DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
CLD	Chronic Lung Disease
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	Susceptible, increased exposure
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-typeable
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
23PPV	23-valent pneumococcal conjugate vaccine
R	Resistant
S	Susceptible, standard dosing regimen

SUMMARY

Invasive pneumococcal disease (IPD) has been a notifiable disease in New Zealand since 17 October 2008. This report provides an update on IPD for the 12 months commencing in January 2021. Data presented in this report are based on IPD case notifications supplemented with serotype and antimicrobial susceptibility data from ESR's national laboratory-based surveillance of invasive *Streptococcus pneumoniae* isolates.

INCIDENCE

There were 468 cases of IPD notified in 2021 - an annual incidence of 9.1 cases per 100,000 population. The 2021 rate was the second lowest annual incidence rate since IPD became a notifiable disease in 2008 (the lowest annual incidence rate of 6.9 per 100,000 population was in 2020). Prior to 2020, the annual incidence peaked at 16.2 cases per 100,000 in 2009, and the lowest annual incidence rate was recorded in 2015 at 9.7 cases per 100,000. The low incidence rate is consistent with the decrease in other infectious diseases in 2020 and 2021 (apart from COVID-19) and is likely due to the impact of the pandemic public health measures, both in New Zealand and internationally.

In 2021, seasonal trends were similar to those seen pre-2020, with a sharp increase in cases from April (24 cases) to May (42 cases), a peak in July (89 cases), and case numbers decreasing from August (83 cases) into September (30 cases). In 2021, there was a large drop off in cases into October (down to 18 cases), and case numbers rose again in December (41 cases). The public health measures implemented to manage the impact of COVD-19 put in place in August 2021 may have contributed to the low number of cases during the spring months.

Incidence by age

In 2021, the highest annual incidence rate was in the <2 years age group at 35.2 cases per 100,000, followed by the ≥65 years age group with a rate of 22.3 cases per 100,000.

The annual incidence rate in children <2 years fluctuated over the previous ten years, from 35.5 in 2012 to a low of 11.8 per 100,000 in 2015. Between 2015 and 2020, rates in children <2 fluctuated between 11.8 and 23.0 per 100,000 before almost doubling from 2020 to 2021.

In children <5 years, the overall annual incidence rate of IPD (due to any serotype) increased from 12.10 per 100,000 in 2020 to 21.6 per 100,000 in 2021 – a rate not seen since 2010 (20.7 per 100,000). Rates fluctuated slightly over 2011–2014, ranging from 12.8 to 18.4 per 100,000, before dropping to 7.8 per 100,000 in 2015. Between 2016 and 2020 rates ranged from 12.1 to 15.1 per 100,000.

In adults ≥65 years there has been a 36.3% decrease in the annual incidence rate of IPD cases between 2012 and 2021 (35.0 to 22.3 per 100,000 cases). Between 2012 and 2019, rates varied from 25.3 to 35.0 per 100,000 before dropping to 16.8 per 100,000 in 2020. Although the annual incidence of IPD from 2012 has fluctuated (ranging from 5.7 to 11.3 per 100,000), the annual incidence of IPD in the ≥65 years age group has decreased from a peak of 35.0 per 100,000 in 2012 to 16.8 in 2020 and increased again to 22.3 in 2021.

Incidence by ethnicity

Māori and Pacific peoples continue to have a higher incidence of IPD compared to other ethnic groups, at 17.6 and 18.2 cases per 100,000 population during 2021, respectively. Between 2012 and 2021, crude rates for Māori and Pacific peoples ranged from 13.4 to 18.1 and 17.8 to 27.8 per 100,000 respectively. In comparison, the incidence rates over 2012-2021 for Asian and European or Other ethnic groups have ranged from 2.6 to 5.1 and 4.8 to 10.0 per 100,000, respectively.

In 2021, 42.9% of IPD cases (18 of 43 cases) in the <2 years age group were of Māori ethnicity.

Incidence by District Health Boards

In 2021, the highest all-age annual rate of IPD was in Tairāwhiti District Health Board (DHB) (29.1 per 100,000, 15 cases), followed by Northland (22.2 per 100,000, 44 cases), Hawke's Bay (16.0 per 100,000, 29 cases), Whanganui (15.9 per 100,000, 11 cases), and Wairarapa (14.0 per 100,000, 7 cases) DHBs.

SEROTYPES

The most common serotypes in 2021 were 19A (139 cases), 8 (78 cases), 22F (26 cases), and 3 (21 cases). These four serotypes accounted for 58.5% (264/451) of IPD cases with known serotypes in 2021. Among children <5 years of age, 59.0% (36/61) of cases with known serotypes were due to serotypes covered under the PCV13 vaccination.

Case vaccination history

There was a marked increase in the number IPD cases that were 19A in 2021 (139 cases) compared to 2017–2020 when there were between 60–75 cases per year.

A pneumococcal conjugate vaccine has been on the New Zealand childhood immunisation schedule since 2008. These conjugate vaccines provide protection against various serotypes of *streptococcus pneumoniae*. The following outlines the history of the PCV vaccine in the immunisation schedule:

- June 2008 to June 2011 - Prevenar® (PCV7),
- July 2011 to June 2014 - Synflorix® (PCV10)
- July 2014 to June 2017 - Prevenar13® (PCV13)
- July 2018 to December 2022 - Synflorix® (PCV10)
- From December 2022, Prevenar13® (PCV13) has been introduced to the childhood immunisation schedule.

until July 2020, the vaccine was delivered in a 3 + 1 dosing schedule when it was changed to a 2 + 1 dosing schedule in July 2020.

Up to two and three 23PPCV doses are funded for children and adults, respectively, who are high risk with eligible conditions.

PCV10 and PCV7 do not provide protection against serotype 19A. Therefore, the incidence of this serotype has been actively monitored since July 2018, when the PCV vaccine changed from PCV13 to PCV10.

Overall, there have been marked reductions in the incidence of IPD due to PCV10 serotypes in in all age group since 2012. Twenty two of the 32 IPD cases due to 19A in children <5 years of age were either fully vaccinated with only PCV10 or on schedule for age with only PCV10, and six had received a combination of PCV10/PCV13.

The incidence of IPD due to 19A IPD cases in the <2 years and 2–4 years age groups have more than tripled between 2019 and 2021 (from 4.1 to 13.1 per 100,000 and from 2.7 to 8.7 per 100,000, respectively). Only two were unvaccinated and two were under-vaccinated (according to the childhood immunisation schedule).

Antimicrobial Resistance

Antimicrobial susceptibility testing was performed on 227 (50.3%) of 451 cultures received from notified cases (*n*=468) in 2021.

Overall, 35.7% of all isolates that were tested were resistant to penicillin.

The majority of 19A isolates were penicillin resistant (84.1%) – an increase from 38.8% in 2012.

CLINICAL OUTCOMES

Overall, the majority of cases (64.8%) with a known presentation presented with pneumonia. However, the most common presentation differed by age – two-thirds of those aged 65 years and over presented with pneumonia, with other presentations less common. Children aged less than 1 year commonly presented with bacteraemia without focus (40.7%) and pneumonia (33.3%) with empyema and meningitis less common. In comparison, similar proportions of those aged between 1 and 2 years presented with bacteraemia without focus (37.5%), pneumonia (31.3%) and empyema (25.0%).

The overall IPD case-fatality rate was 5.9%. The majority of deaths (59.3%) were in adults aged 70 years and over. Of the 27 cases that died from IPD, five were Māori, five were Pacific peoples, sixteen were European or Other and one was Asian.

INTRODUCTION

Invasive pneumococcal disease (IPD) is caused by *Streptococcus pneumoniae.* IPD is defined by isolation of *S. pneumoniae* from a usually sterile site, such as blood, pleural fluid or cerebrospinal fluid, and represents the most severe end of the disease spectrum caused by this bacterium. The most common clinical presentations in IPD are bacteraemic pneumonia, non-localised bacteraemia (bacteraemia without focus), and meningitis. Older adults generally have bacteraemic pneumonia, while young children may have any of the three, with meningitis being the most severe. Non-invasive infections include acute otitis media (predominantly in children) and sinusitis (predominantly older children and adults).

IPD is a vaccine preventable disease with vaccines that provide protection against different serotypes of the bacterium available. There are currently two types of pneumococcal vaccine approved for use in New Zealand for use against *S. pneumoniae*: pneumococcal conjugate vaccine (PCV) with ten or 13 serotypes and a plain polysaccharide pneumococcal vaccine (PPV) containing 23 serotypes.

The history of the pneumococcal vaccine on the New Zealand childhood immunisation schedule since 2008 and its history is summarised in Table 1.

Table 1. Pneumococcal conjugate vaccine history in New Zealand[1]

Date	Vaccination schedule change
2006	PCV7 and 23PPV introduced for high-risk individuals.
2008	Introduced to the Schedule in June as PCV7 at ages 6 weeks, 3 months, 5 months and 15 months.
2011	PCV10 replaced PCV7 on the Schedule. PCV13 replaced PCV7 for high-risk children.
2014	PCV13 replaced PCV10 on the Schedule.
2015	PCV13 became available for patients of any age with certain high-risk conditions.
2017	PCV10 replaced PCV13 on the Schedule. PCV13 and 23PPV continues for high-risk individuals
2020	PCV10 recommended as a 2-dose primary schedule plus booster dose given at 6 weeks, 5 months and 12 months. PCV13 remained at 3-dose schedule plus booster for high-risk infants (ie given at ages 6 weeks, 3, 5 and 12 months)
2022	PCV13 replaced PCV10 on the Schedule in a 2-dose primary plus booster in December. An additional 3-month dose continued for high-risk infants.

[1] [1]

This report presents information on cases of IPD that were notified in 2021, as well as trend data for 2012–2020. Previous annual reports for 2008 – 2020 [2-12], and anti-antimicrobial susceptibility reports for 2002–2007 [13-17] are also available. The data are collated and analysed on behalf of the Ministry of Health by ESR.

METHODS

IPD has been a notifiable disease since 2008. A confirmed case is one that has a clinically compatible illness that is laboratory confirmed. Most cases present with either meningitis, pneumonia, or septicaemia. Laboratory confirmation requires at least one of the following [18]:

- isolation of *S. pneumoniae* from blood, cerebrospinal fluid (CSF) or another normally sterile site (e.g., joint fluid, pleural fluid (since 2016))
- detection of *S. pneumoniae* nucleic acid from blood, CSF or another normally sterile site
- a positive *S. pneumoniae* antigen test on CSF (since 2009) or pleural fluid (since 2016)

Of note, pleural fluid as a sterile site was only added in 2016. [18] As a result, this addition may have slightly increased the total number of IPD cases relative to previous years.

This report includes analyses using data from 2012 to 2021 for IPD case notifications from EpiSurv. These data are supplemented with serotype and antimicrobial susceptibility data from the ESR national laboratory-based surveillance of invasive *S. pneumoniae* isolates.

NOTIFICATIONS

The notification data in this report is based on the information recorded on EpiSurv as at 4 November 2022. 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.

Notification data is entered by each public health unit (PHU) onto a case report form (https://surv.esr.cri.nz/episurv/crf.php) via a secure web-based portal onto a computerised database (EpiSurv).

The use of notification data to identify and accurately quantify risk factors for IPD may be limited due to a lack of completeness of data. Moreover, not only are questions about risks often not answered, but when they are answered they often lack context. For example, a child who has been identified as “immunocompromised” may not necessarily be at an increased risk for IPD. A closer examination of the medical records for these cases would be needed to determine true risk. Additionally, some risk factors are especially susceptible to recall bias. That is, a clinician may report all risks, both large and small, after a case is identified, potentially falsely over-representing some risks relative to non-cases in the community. Lastly, the cause of death is unknown in a large proportion of fatalities.

LABORATORY METHODS

Diagnostic microbiology laboratories in New Zealand are requested to refer all invasive isolates of *S. pneumoniae* (i.e., isolates from CSF, blood, or another normally sterile site) to ESR for the national laboratory-based surveillance of IPD. At ESR, all invasive isolates are serotyped and 50% are tested for susceptibility to a range of antibiotics.

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 [19]. Some serotypes form serogroups and factor antisera are required to identify the serotype within that serogroup. The full complement of factorised antisera is not held by ESR. 'Non-typeable' is used in following or in place of a serogroup where full serotype information is undetermined.

Antimicrobial susceptibility testing

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 [20]. Inducible clindamycin resistance was detected by the D-zone test [20]. All minimum inhibitory concentrations (MICs) and zone of inhibition diameters were interpreted according to the current EUCAST clinical breakpoints [21].

The antimicrobial susceptibility data presented in this report for the years prior to 2016 is based on Clinical and Laboratory Standards Institute (CLSI) methods and breakpoints [22] 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. The EUCAST clinical breakpoints for co-trimoxazole changed in 2019 and are noted in the results.

In this report, multidrug resistance (MDR) is defined as resistance to three antibiotics in addition to penicillin [23]. 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 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 2017 may differ slightly from those published in earlier annual reports as the mid-year population estimates are updated each year.

Ethnicity

The denominator data used to determine disease rates for ethnic groups is based on the proportion of people in each ethnic group from the resident 2018 census population applied to the 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. Ethnicity for any cases that cannot be matched to the NHI database remain unknown. Ethnicity is prioritised in the following order: Māori, Pacific peoples, Asian, and European or Other ethnicity (including New Zealander and Middle Eastern/Latin American/African (MELAA)). Limitations in data collection may have resulted in underreporting of Pacific cases identifying as both Māori and Pacific peoples where total response ethnicity has been used.

Neighbourhood deprivation

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

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.

Immunisation status

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 (i.e., PCV7, PCV10, PCV13 or 23PPV), 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 or after disease onset were not counted in the analysis.

Vaccine abbreviations are as follows:

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.

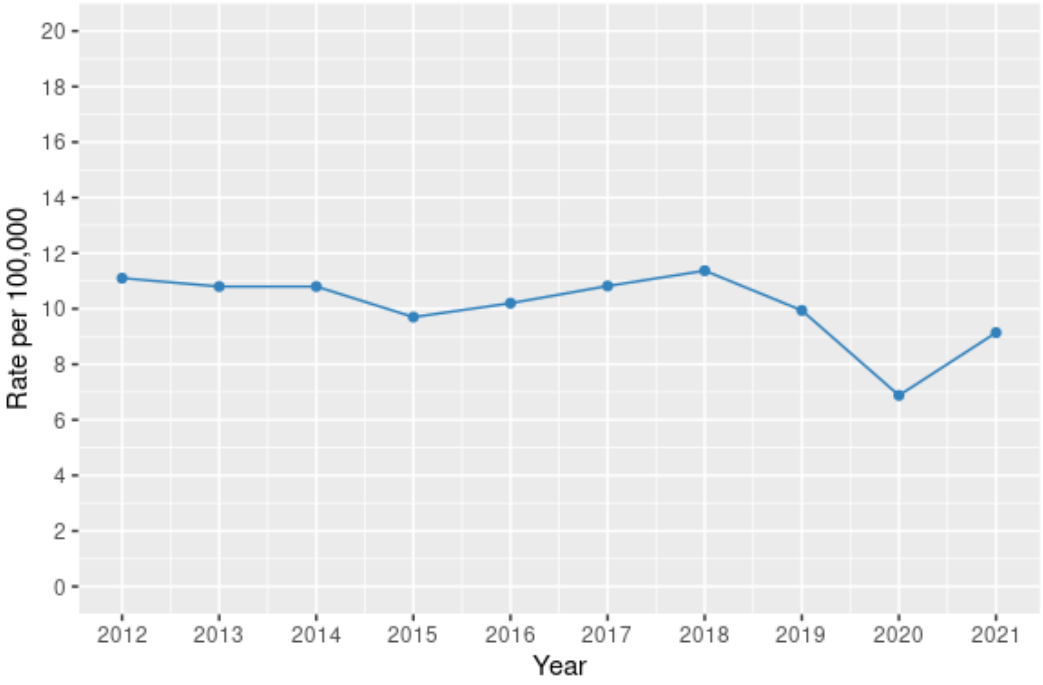
PCV13: 13-valent pneumococcal conjugate vaccine with serotypes 1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F and 23F.

23PPV: 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.

INVASIVE PNEUMOCOCCAL DISEASE EPIDEMIOLOGY

In 2021, 468 cases of IPD were notified - an annual incidence rate of 9.1 cases per 100,000 population. Although the 2021 incidence rate was higher than the rate observed in 2020, the 2021 rate remains lower than in 2012 to 2019 (Figure 1).

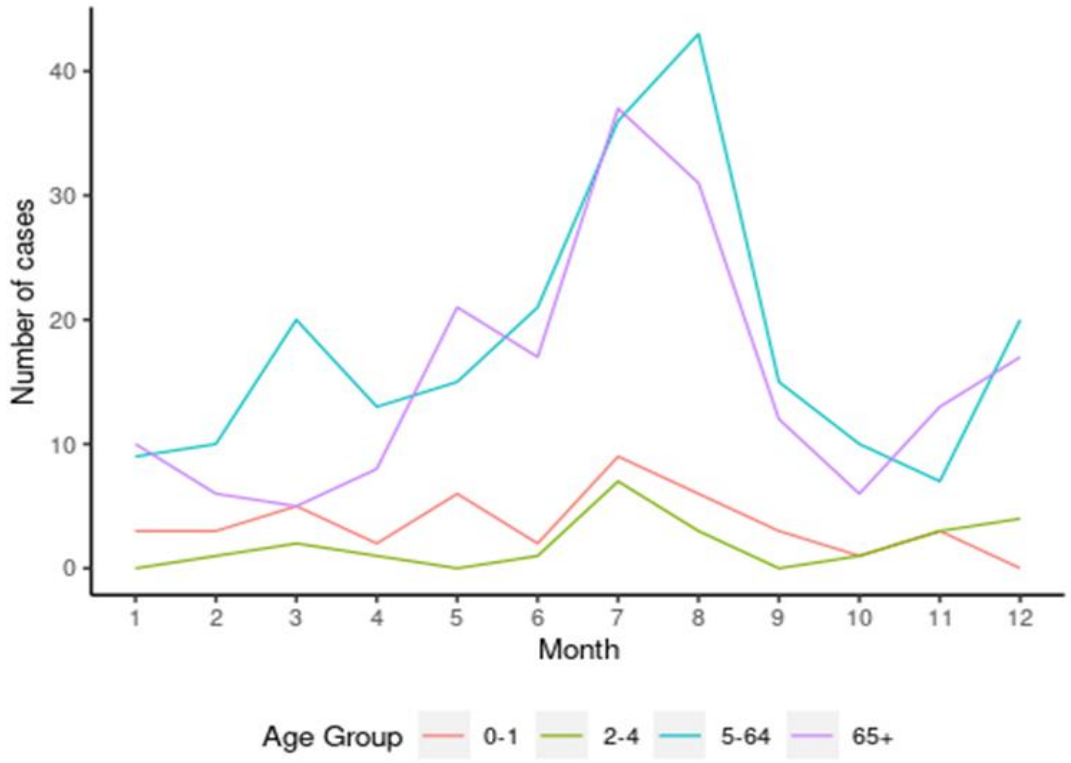
Figure 1. Crude incidence rate per 100,000 population, 2012–2021



DISEASE INCIDENCE BY SEASON

In 2021 there was a peak of cases of IPD in the winter months in all ages, particularly in those aged five years and over (Figure 2). This seasonal trend is similar to that seen in previous years. Overall, there was a sharp increase in cases from April (24 cases), peaking in July (89 cases). In 2021, there was an increase in the number of cases in December (41 cases).

Figure 2. Number of invasive pneumococcal disease cases by age group and month, 2021



DISEASE INCIDENCE BY AGE AND SEX

The highest annual incidence rate in 2021 was in infants aged less than two years (35.2 cases per 100,000), followed by the ≥65 years age group (22.3 cases per 100,000).

As observed in previous years, the rates of IPD were greater for males compared to females in all age groups (Table 2). The highest incidence rate for both females and males were in infants aged less than 2 years (26.9 cases per 100,000 and 43.1 cases per 100,000, respectively). The 5–64 years age group had the lowest incidence rates for both females and males (4.9 and 6.1 cases per 100,000, respectively).

Table 2. Number of cases and rate per 100,000 population of invasive pneumococcal disease by age group and sex, 2021

Age group (years)	Female		Male		Total		
	Cases	Rate[a]	Cases	Rate[a]	Cases	Rate[a]	Percent[b]
<2	16	26.9	27	43.1	43	35.2	9.2
2–4	10	11.2	13	13.8	23	12.5	4.9
<5	26	17.5	40	25.5	66	21.6	14.1
5–64	97	4.9	122	6.1	219	5.5	46.8
≥65	95	21.8	88	22.9	183	22.3	39.1
Total	218	8.4	250	9.8	468	9.1	100

[a] Rate per 100,000 population
[b] Percent of total cases in each group

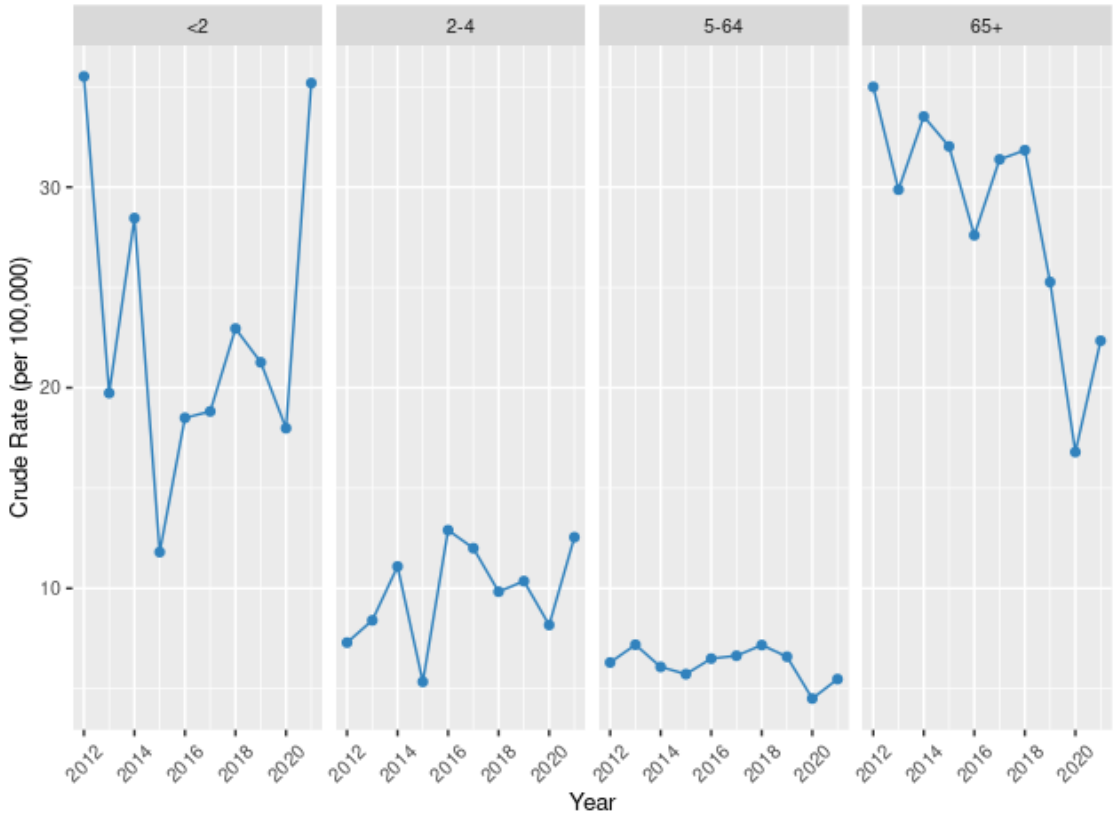
Between 2012 and 2021, annual incidence rate trends have differed across the four age groups (Figure 3). However, all groups experienced an increase in rates from 2020 to 2021.

There was a decrease in the annual incidence rate for the <2 years age group from a peak in 2012 (35.5 per 100,000), to a low of 11.8 per 100,000 in 2015. Since 2015, the annual incidence rate in this group has been increasing and in 2021, the rate was similar to that seen in 2012.

The rate for 2–4-year-olds has fluctuated but has followed an overall increasing trend, from 7.3 per 100,000 in 2012 to 12.5 per 100,000 in 2021. The rate for 5–64 years has remained relatively stable, from 6.3 per 100,000 in 2012 to 5.5 per 100,000 in 2021.

In comparison to the other age groups, the annual incidence rate for those aged 65 years and over has steadily decreased from 35.0 per 100,000 in 2012 to 22.3 per 100,000 in 2021.

Figure 3. Crude rate per 100,000 population of invasive pneumococcal disease by age group and year, 2012–2021



DISEASE INCIDENCE BY ETHNIC GROUP

Ethnicity was recorded for 466 (99.8%) of IPD cases in 2021. Of the 222 European or Other cases, five cases self-identified as Middle Eastern/Latin American/African (MELAA), one of which was <2 years and four of which were aged 5–64 years.

Among the 150 cases who self-identified as Māori, seven also self-identified as Pacific peoples.

Among the 42 cases <2 years of age, 18 cases (42.9%) were Māori, 13 (30.1%) were European or Other, 7 (16.7%) were Pacific peoples and 4 cases (9.5%) were of Asian ethnicity.

Overall, Pacific peoples had the highest rates of IPD (18.2 per 100,000) followed by Māori (17.6 per 100,000). The rates for Pacific and Māori were respectively 4.2 (95% CI 3.7 – 4.7) and 4.9 (95% CI 4.3 – 5.5) times higher than the European or Other group, after adjusting for age[1].

Table 3. Number of cases, and age-specific rate per 100,000 population of invasive pneumococcal disease by ethnic group and age group, 2021

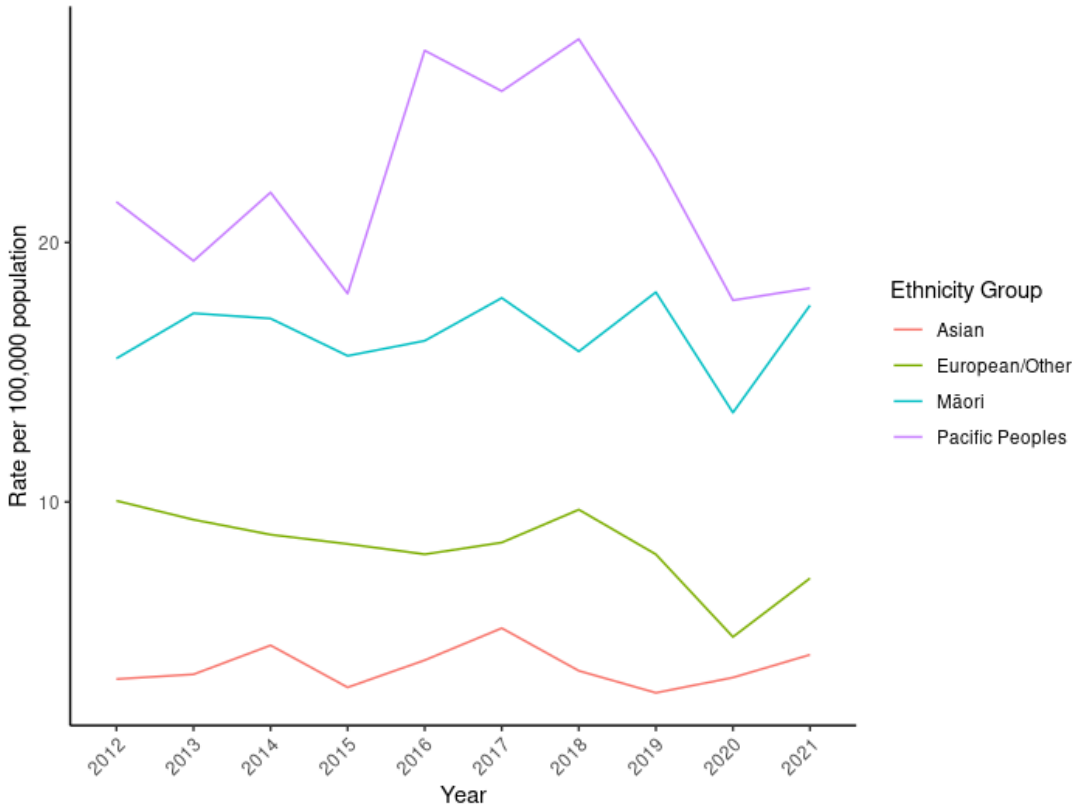
Age group (years)	Māori		Pacific		Asian		European or Other	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
<2	18	53.4	7	59.1	4	-	13	23.7
2–4	7	13.2	1	-	4	-	11	11.6
<5	25	28.8	8	27.5	8	15.9	24	16.1
5–64	89	12.7	33	11.4	13	2.0	84	3.6
≥65	36	64.7	22	94.7	11	19.8	114	16.6
Total cases and crude rate for all ages[a]	150	17.6	63	18.2	32	4.1	222	7.1

[a] Ethnicity was recorded for 466 (99.8%) of cases notified in 2021.

[1] 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 2018 census population applied to the 2020 mid-year population estimates from Statistics New Zealand. Ethnicity is prioritised in the following order: Māori, Pacific peoples, Asian, and European or Other ethnicity (including New Zealander and MELAA). Where there were fewer than five cases in any category, a rate has not been calculated.

There has been an overall decreasing trend in the annual incidence rate between 2012 and 2021 for European/Other (Figure 4). After peaking in 2016 and 2018, the annual incidence rates in Pacific people have been decreasing. In comparison, although there have been some fluctuations, the rates for Māori and Pacific peoples have remained stable between 2012 and 2021(Figure 4).

Figure 4. Crude rate per 100,000 population of invasive pneumococcal disease by ethnic group, 2012–2021

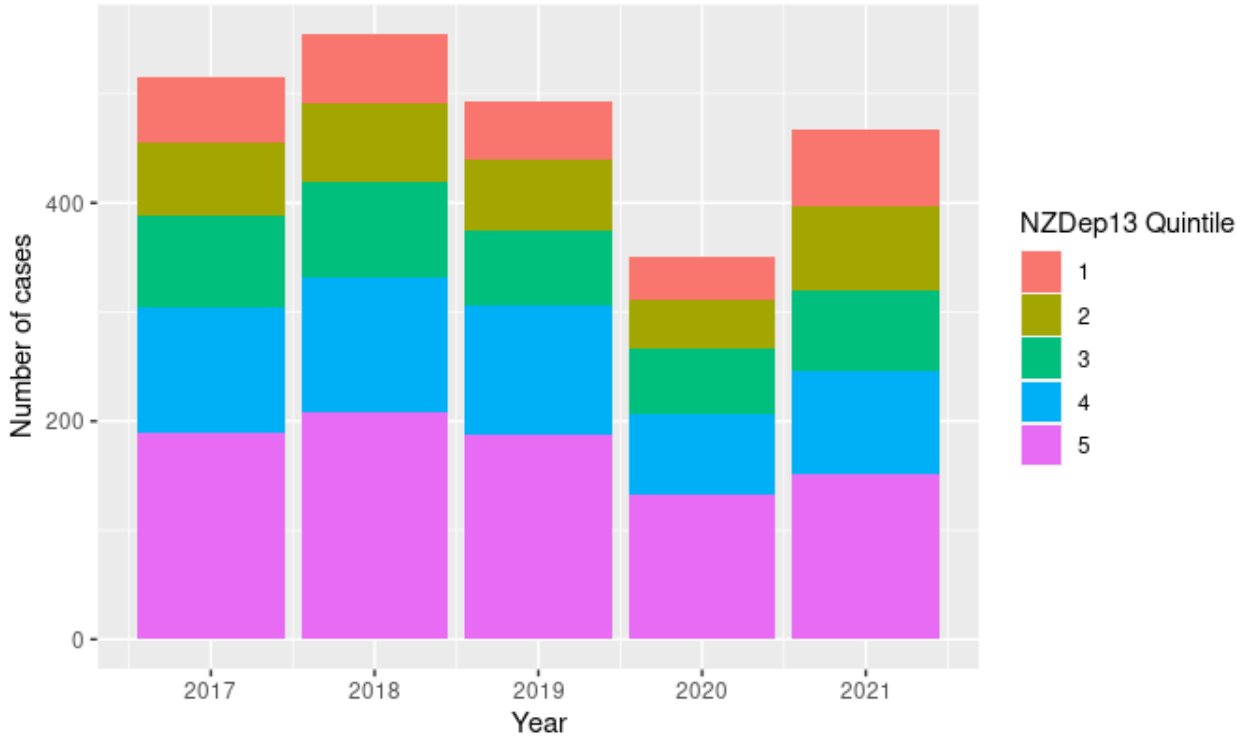


Note: European/Other includes MELAA.

DISEASE INCIDENCE BY DEPRIVATION

In 2021, 467 (99.8%) IPD cases had a residential address recorded that could be assigned an NZDep13 score. In 2021, 52.7% of IPD cases with an assigned NZDep13 score resided in NZDep13 quintiles 4 or 5, compared to 31.7% in quintiles 1 and 2. (Figure 5).

Figure 5. Number of invasive pneumococcal disease cases by quintiles of the 2013 New Zealand deprivation index, 2021[a]



[a] Cases with 'unknown' NZDep13 quintile were removed from the figure

DISEASE INCIDENCE BY DISTRICT HEALTH BOARD

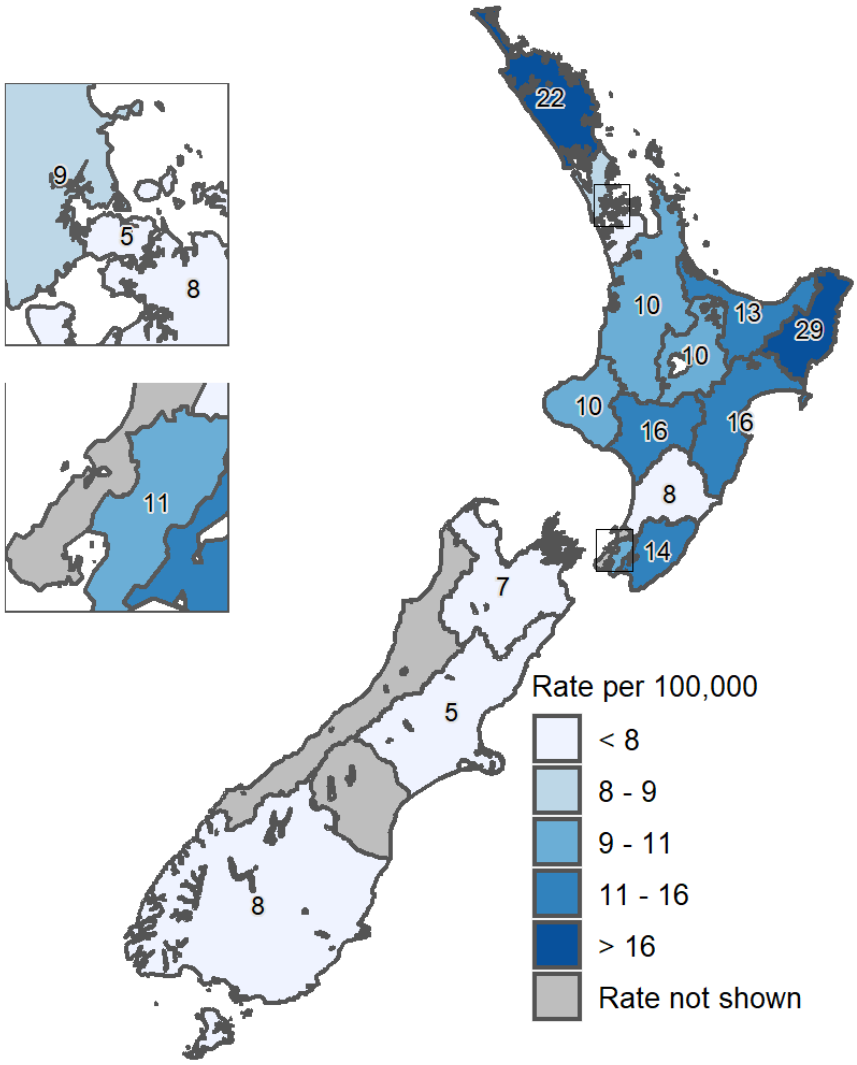
In 2021 the highest rate of IPD was in Tairāwhiti District Health Board (DHB) (29.1 per 100,000, 15 cases), followed by Northland (22.2 per 100,000, 44 cases), Hawke's Bay (16.0 per 100,000, 29 cases), Whanganui (15.9 per 100,000, 11 cases), and Wairarapa (14.0 per 100,000, 7 cases) DHBs (Table 4 and Figure 6). Across the regions, rates ranged from 6.1 in the Southern region to 11.9 in the Midland region (Table 4.

Table 4. Number of cases of invasive pneumococcal disease by age group and rate per 100,000 population for each District Health Board, 2021

District Health Board	Cases by age group (years)					Rate (all ages)[a]
	<2	<5	5–64	65+	All ages	
Northland	2	3	14	27	44	22.2
Waitemata	6	8	30	18	56	8.8
Auckland	3	3	13	8	24	4.8
Counties Manukau	3	10	23	13	46	7.7
Northern region	**14**	**24**	**80**	**66**	**170**	**8.8**
Waikato	6	7	21	18	46	10.3
Lakes	1	2	9	1	12	10.1
Bay of Plenty	1	2	18	14	34	12.6
Tairāwhiti	1	1	10	4	15	29.1
Taranaki	1	2	5	6	13	10.3
Midland region	**10**	**14**	**63**	**43**	**120**	**11.9**
Hawke's Bay	5	5	9	15	29	16.0
Whanganui	1	1	3	7	11	15.9
MidCentral	0	1	9	5	15	7.9
Hutt Valley	1	2	6	9	17	10.6
Capital & Coast	3	4	10	10	24	7.3
Wairarapa	0	1	5	1	7	14.0
Nelson Marlborough	3	3	5	4	12	7.3
Central region	**13**	**17**	**47**	**51**	**115**	**10.1**
West Coast	0	0	1	2	3	-
Canterbury	1	4	15	10	29	4.9
South Canterbury	0	0	2	1	3	-
Southern	5	7	11	10	28	8.0
Southern region	**6**	**11**	**29**	**23**	**63**	**6.1**
Total	**42**	**65**	**219**	**183**	**468**	**9.1**

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

Figure 6. Geographic distribution of invasive pneumococcal disease cases, 2021



Between 2020 and 2021 the rates of IPD cases increased in all regions. From 2017 to 2021 the Southern region consistently had the lowest annual incidence rate, while the Midland region consistently had the highest annual incidence rate.

SEROTYPE DISTRIBUTION

In 2021, 468 cases were referred to ESR for serotyping. Of these, 17 (3.6%) were not able to be typed. Of those that were able to be typed, 33 serotypes were identified.
In 2021, 19A was the most common serotype, making up 29.7% of all cases that were able to be serotyped. Serotype 19A was the most common serotype seen in all age groups. Serotype 8 was the second most common at 16.7 % overall (Table 5).

Table 5. Number and percentage of invasive pneumococcal disease cases by serotype and age group, 2021

Serotype	<2 years		2–4 years		5–64 years		≥65 years[a]		Total	
	Cases	%[b]	Cases	%[b]	Cases	%[b]	Cases	%[b]	Cases	%[b]
19A	16	37.2	16	69.6	57	26.0	50	27.3	139	29.7
8	3	7.0	0	-	55	25.1	20	10.9	78	16.7
22F	1	2.3	0	-	7	3.2	18	9.8	26	5.6
3	3	7.0	0	-	6	2.7	12	6.6	21	4.5
16F	1	2.3	0	-	9	4.1	9	4.9	19	4.1
6C	1	2.3	2	8.7	9	4.1	6	3.3	18	3.8
15B	5	11.6	1	4.3	6	2.7	5	2.7	17	3.6
23B	1	2.3	0	-	7	3.2	9	4.9	17	3.6
11A	1	2.3	0	-	4	1.8	9	4.9	14	3.0
12F	2	4.7	0	-	9	4.1	3	1.6	14	3.0
19F	0	-	0	-	2	0.9	8	4.4	10	2.1
9N	1	2.3	0	-	6	2.7	1	0.5	8	1.7
10A	2	4.7	1	4.3	2	0.9	3	1.6	8	1.7
7F	1	2.3	0	-	5	2.3	1	0.5	7	1.5
23A	0	-	0	-	2	0.9	5	2.7	7	1.5
33F	0	-	0	-	5	2.3	1	0.5	6	1.3
35B	0	-	0	-	1	0.5	5	2.7	6	1.3
21	1	2.3	1	4.3	2	0.9	0	-	4	0.9
4	0	-	0	-	2	0.9	1	0.5	3	0.6
7C	0	-	0	-	2	0.9	1	0.5	3	0.6
13	1	2.3	0	-	0	-	2	1.1	3	0.6
15A	0	-	0	-	0	-	3	1.6	3	0.6
34	0	-	0	-	2	0.9	1	0.5	3	0.6
14	0	-	0	-	1	0.5	1	0.5	2	0.4
18C	0	-	0	-	1	0.5	1	0.5	2	0.4
17F	0	-	0	-	1	0.5	1	0.5	2	0.4
20	0	-	0	-	2	0.9	0	-	2	0.4
35F	0	-	0	-	1	0.5	1	0.5	2	0.4
6B	0	-	0	-	0	-	1	0.5	1	0.2
31	0	-	0	-	1	0.5	0	-	1	0.2
37	0	-	0	-	0	-	1	0.5	1	0.2
38	0	-	0	-	1	0.5	0	-	1	0.2
6D	0	-	0	-	1	0.5	0	-	1	0.2
Other[c]	0	0.0	0	-	1	0.5	1	0.5	2	0.4
NA[d]	3	7.0	2	8.7	9	4.1	3	1.6	17	3.6
Total[e]	**43**	**100**	**23**	**100**	**219**	**100**	**183**	**100**	**468**	**100**

[a] Among the cases in the ≥65 years age group, 74.3% were due to 23PPV serotypes. Vaccination with 23PPV is recommended for people in this age group.
[b] Percentage of cases within the age group with the serotype.
[c] Includes non-typeable serotypes.
[d] Includes cases where serotype information was not available
[e] Total number of isolates from culture-positive cases referred to ESR for serotyping for each age group.

Serotype trends

Since 2012, there has overall been a decline in rates of disease caused by the serotypes covered by the PCV10 vaccine (and, as a result, also by the PCV7 vaccine). This group of serotypes have rarely been seen in children aged under five since 2017.

Serotypes 1, 5, 6A, 23F, and 9V were not identified in any cases in 2021. Serotypes 1 and 23F have not been seen since 2020 (when there was one case each), and 6A and 9V since 2019 (when there was one case each). Serotype 5 has not been seen since 2016 (when there were two cases). Serotypes 1, 5, 9V, and 23F are all included in the PCV10 vaccine. Serotype 6A is included in the PCV13 vaccine. There has been a steady increase in serotype 19A since 2017, driven by increases in children aged under 5 years. In 2021, 19A made up 37.2% of all serotyped IPD cases in those aged less than 2 and 69.6% in 2–4 year olds.

There was also an increase in cases due to serotype 19A aged 65 years and over between 2020 and 2021, making up 27.3% of cases in this age group in 2021.

Serotype 8 has also been increasing in New Zealand, from 29 cases in 2016 to 78 in 2021 (Figure 7). Serotype 8 is covered in 23PPV, which is only available for eligible high-risk populations with eligible conditions.

Figure 7. Trends in serotypes, rate per 100,000, by age group and year, 2012–2021

Note: cases with an "unknown" serotype have been removed from the figure. 'PCV10 serotypes' are cases due to serotypes covered by PCV10 (1, 4, 5, 6B, 7F, 9V, 14, 18C, 19F and 23F); Other serotypes are cases due to serotypes not covered in PCV vaccinations (6C, 6D, 7C, 8, 9N, 10A, 10F, 11A, 12F, 13, 15A, 15B, 15C, 16F, 17F, 18A, 18F, 20, 21, 22A, 22F, 23A, 23B, 31, 33F, 35B, 37, 38, 42) as well as two PCV13 serotypes (3, 6A)

Monitoring of serotype 19A

A threshold for cases due to the three additional serotypes covered by PCV13 (3, 6A, and 19A) were established for monitoring the reintroduction of the PCV10 vaccination in place of PCV13 in July 2017. The number of cases caused by serotype 3 has been decreasing since the reintroduction of PCV10, from 33 cases in 2017 to 21 cases in 2021. Serotype 6A has not been seen since 2019 (one case). The threshold for 19A has been established at 9.1 cases per 100,000 children less than 2 years of age, with rates based on cumulative cases over 4-quarter time periods. The 19A threshold was first exceeded in quarter 2 of 2021, and the rate of 19A in children less than 2 years has increased through to quarter 4 of 2022, where it reached a high of 33.2 per 100,000. PCV13 was reintroduced in December 2022 in place of PCV10 after evaluation. Quarterly reports with further analyses are available on ESR's surveillance website: *https://surv.esr.cri.nz/surveillance/IPD.php*

CASE VACCINATION HISTORY

The vaccination status was able to be determined for IPD cases who were age-eligible to receive the PCV vaccine (ie, cases born after 1 January 2008). This analysis only includes doses received more than 14 days before onset of IPD (determined using the earliest episode date available from onset of illness date, hospitalised date, or date reported to the public health unit).

The PCV vaccines that were received included PCV7 (from 2008 to 2011), PCV10 (from 2011 to 2014 and 2017 to the present), PCV13 (from 2014 to 2017). High risk individuals have had access to at least one of 23PPV and PCV13 since 2006.[1]

Immunisation records were identified in the NIR for 75 IPD cases notified in 2021 (Table 6). An additional 9 IPD cases were age-eligible for PCV vaccine but had no immunisation information within the NIR nor in EpiSurv – these cases are assumed to be unvaccinated. There were no cases identified as having received 23PPV vaccination.

Approximately half (48%) of the 75 PCV vaccine-eligible IPD cases notified in 2021 for whom vaccination data was available, were infected with serotypes not included in the PCV vaccines available in New Zealand.

The majority of the remaining 39 cases were infected with either serotype 19A (36 cases) or with serotype 3 (2 cases)– serotypes that are included in the PCV13 vaccine. Only one case was infected with a serotype that was included in the PCV7 and PCV10 vaccines - serotype 19F – and this case was vaccinated with 3 PCV7 doses and 1 PCV10 dose.

Of the 36 cases that were infected with serotype19A, 2 were fully vaccinated with four PCV13 doses, 27 were either fully vaccinated with PCV7 or PCV10 or on schedule for vaccination for their age. Seven had received a combination of PCV13 and 10[2], and one

[2] One case had received one PCV13 then three PCV10; three cases had received three PCV13 then one PCV10; two cases had received two PCV13 then two PCV10; oOne case had received one PCV13 then one PCV10

was fully vaccinated with four PCV7 vaccine doses. Two 19A cases under 1 year old were unvaccinated.

Five of the serotype 19A cases in children under 5 were identified as having risk factors that would have made them eligible for a funded extended schedule using PCV13 vaccine (noting that this field in the EpiSurv case report form is not often completed). All these children had received the PCV10 vaccine – four were fully vaccinated and one was ‘under vaccinated’. Although they are recorded as having risk factors, it is unknown whether these were known prior to their IPD illness which would have made them eligible for PCV13 or 23PPV.

Table 6. Immunisation status of the 2021 IPD cases who were age-eligible for PCV and have an NIR record

Doses received (PCV vaccine) [a]	Number of cases per serotype per dose received (number of cases on schedule for vaccination completion)							
	PCV7 Serotypes	PCV10 Serotypes	PCV13 Serotypes			Non-PCV Serotypes	Unknown	Total
			19A	3	6A			
PCV7								
1								
2								
3								
4			1 (1)			1 (1)		2 (2)
PCV10								
1						3 (2)		3 (2)
2			8 (8)	1 (1)		7 (6)	1 (1)	17 (16)
3			4 (3)			2 (0)		6 (3)
4			14 (14)	1 (1)		8 (8)	2 (2)	25 (25)
PCV13								
1								
2								
3						1 (1)	1 (0)	2 (1)
4			2 (2)			2 (2)		4 (4)
Multiple PCV vaccines								
PCV7/PCV10	1 (1)							1 (1)
PCV10/PCV13			7 (7)[b]			6 (6)[c]	1 (1)[d]	14 (14)
PCV7/PCV10/PCV13						1 (1)[e]		1 (1)
Total	1 (1)		36 (35)	2 (2)		31 (27)	5 (4)	75 (68)

Note: blank cells represent zero observations.

[a] Only the number of doses received prior to 14 days before onset of IPD are included. The 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] One case received one PCV13 then three PCV10 doses, three cases received three PCV13 then one PCV10 dose, two case received two PCV13 then two PCV10, one had received one PCV13 and then one PCV10.

[c] Three case received three doses of PCV10 then one of PCV13, one case received three cases of PCV10 then two of PCV13, one case received three doses of PCV13 then one of PCV10, one case received two doses of PCV13 then two of PCV10.

[d] One case has received two doses of PCV13 then two doses of PCV10.

[e] One case has received three doses of PCV7 then one of PCV10 then one of PCV13.

ANTIMICROBIAL SUSCEPTIBILITY

The first line of treatment for IPD is a combination antibacterial medication and can include augmentin, ceftriaxone or azithromycin. Surveillance of antimicrobial susceptibility of case isolates is essential to inform treatment as well as to inform immunisation policy to ensure protection against serotypes which are showing increasing antimicrobial resistance.

ESR has a target to undertake antimicrobial susceptibility testing on 50% of S pneumoniae isolates. In 2021, antimicrobial susceptibility testing was done on 227 isolates – 50.3% of 451 isolates received. EUCAST meningitis breakpoints are used to interpret antimicrobial susceptibility results. Table 7 summarises these results. Just over one third (35.7%,, n = 81) of the isolates were resistant to penicillin.

Four of these penicillin-resistant isolates (meningitis breakpoints) were also resistant to a co-trimoxazole, erythromycin and tetracycline.

Only 1.3% of the 227 isolates tested were cefotaxime resistant.

There was a change to EUCAST susceptibility testing methods in 2016, which means that not all susceptibility testing results from 2016 to 2021 are 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 2012–2021 period are presented.

Overall, penicillin resistance in *S pneumoniae* has significantly increased from a low of 17.4% in 2012 to a high of 35.7% in 2021 (*p* value < 0.001). In comparison - rates of cefotaxime resistance have remained low and are lower in 2021 (1.3%) compared to what they were in 2012 (4.1%). Co-trimoxazole resistance has also increased over the last three years from a low of 14.6% resistance in 2019 to a high of 30.8% resistance in 2021. In 2021 29.5% of isolates were resistant to both penicillin and co-trimoxazole. Resistance to all other antibiotics tested has decreased over the last five years, or was very low.

All isolates were susceptible to moxifloxacin, rifampicin and vancomycin. Rifampicin susceptibility has been tested since 2010, with no resistance identified.

Table 7. Antimicrobial susceptibility among isolates from invasive pneumococcal disease cases, 2021

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	64.3	-	35.7
non-meningitis[c]	≤0.06	0.12–2	≥4	64.3	35.2	0.4
Cefotaxime						
meningitis	≤0.5	-	≥1	100.0	-	1.3%
non-meningitis	≤0.5	1–2	≥4	98.7	1.3	0.0
	Zone diameter (mm)					
Chloramphenicol	≥21	-	≤20	99.6	-	0.4
Clindamycin[d]	≥19	-	≤18	97.4	-	2.6
Co-trimoxazole	≥13	10–12	≤9	68.7	0.4	30.8
Erythromycin	≥22	19–21	≤18	95.2	0.4	4.4
Moxifloxacin	≥22	-	≤21	100	-	0.0
Rifampicin	≥22	17–21	≤16	100	0.0	0.0
Tetracycline	≥25	22–24	≤21	95.2	0.4	4.4
Vancomycin	≥16	-	≤15	100	-	0.0

[a] European Committee on Antimicrobial Susceptibility Testing [21] .
[b] S = susceptible standard dosing (high likelihood therapeutic success using standard dosing), I = susceptible increased exposure (likelihood of therapeutic success with adjustments to dosing or concentrations), 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, 96.0% 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 among isolates from cases in the different age groups is shown in Table 8. Penicillin resistance was higher among isolates from cases 2–4 years old.

Table 8. Penicillin and cefotaxime resistance among isolates

Age group (years)	Penicillin		Cefotaxime			
	Resistant[a] MIC ≥0.12 mg/L		Susceptible increased exposure MIC 1–2 mg/L		Resistant[b] MIC ≥4 mg/L	
	Number	%[c]	Number	%[c]	Number	%[c]
<2 (n=20)	7	35.0	1	5.0	0	0.0
2−4 (n=10)	8	80.0	0	0.0	0	0.0
5−64 (n=106)	29	27.4	0	0.0	0	0.0
≥65 (n=91)	37	40.7	2	2.2	0	0.0
All ages (n=227)	81	35.7	3	1.3	0	0.0

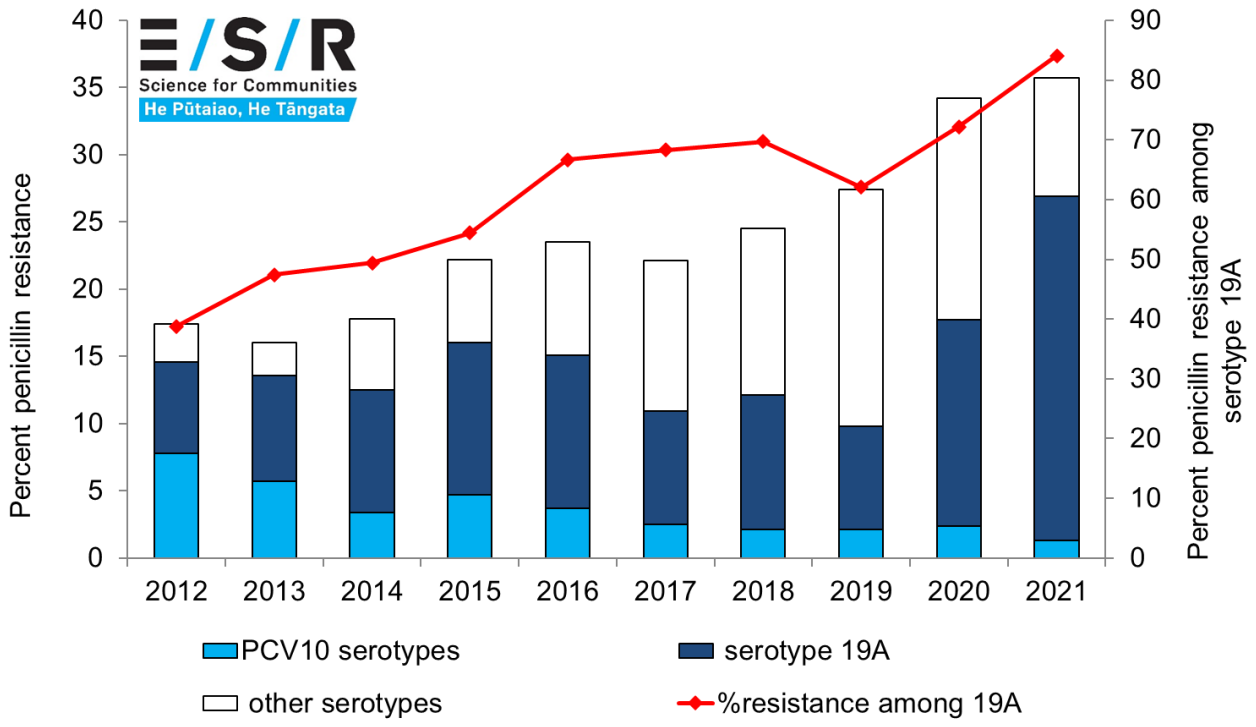
[a] EUCAST meningitis breakpoints; no susceptible increased exposure (I) category [21].
[b] EUCAST non-meningitis breakpoints [21]
[c] Percentage of the isolates from the cases within the age group.

Age group (years)	Penicillin		Cefotaxime	
	Resistant[a] MIC ≥0.12 mg/L		Resistant[a] MIC ≥1 mg/L	
	Number	%[b]	Number	%[b]
<2 (n=20)	7	35.0	1	5.0
2−4 (n=10)	8	80.0	0	0.0
5−64 (n=106)	29	27.4	0	0.0
≥65 (n=91)	37	40.7	2	2.2
All ages (n=227)	81	35.7	3	1.3

[a] EUCAST meningitis breakpoints; no susceptible increased exposure (I) category [21].
[b] Percentage of the isolates from the cases within the age group.

Penicillin resistance in invasive pneumococci has increased over the last decade. This increase has largely driven by an increase in the prevalence of serotype 19A isolates and increasing penicillin resistance in these isolates which has increased from 38.8% 2012 to 84.1% of 19A isolates in 2021 (Figure 8). All but one of the penicillin-resistant, serotype 19A isolates were also resistant to co-trimoxazole. Penicillin-resistant, serotype 19A isolates were susceptible to all other antibiotics tested except for one isolate that was also erythromycin resistant and two isolates that were both erythromycin and tetracycline resistant. In 2021 the next most prevalent serotype among the penicillin-resistant isolates was type 35B, which accounted for 6.2% of penicillin-resistant isolates. All serotype 8 isolates were fully susceptible to the antimicrobials tested.

Figure 8. Penicillin-resistance among pneumococci from invasive disease cases, 2012–2021



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.

DISEASE PRESENTATIONS, HOSPITALISATIONS AND DEATHS

The most common clinical presentations in IPD are bacteraemic pneumonia, non-localised bacteraemia (bacteraemia without focus), and meningitis. Older adults generally have bacteraemic pneumonia, while young children may have any of the three, with meningitis being the most severe. Non-invasive infections include acute otitis media (predominantly in children) and sinusitis (predominantly older children and adults).

466 (99.6%) of the 468 IPD cases notified in 2021 had at least one clinical presentation recorded. 56 out of 466 cases (12.0%) had more than one clinical presentation, the most common combinations were empyema and pneumonia (24 cases) and pneumonia and other (24 cases). For the purposes of this report, only one presentation was counted for each case, with presentations prioritised in the following order: meningitis, empyema, pneumonia, bacteraemia without focus and 'Other' (Table 9).

In 2021 clinical presentation differed by age group. The most common clinical presentation for children under 1 years was bacteraemia without focus (40.7%), followed by pneumonia (33.3%), and meningitis (14.8%). In comparison, although children aged 1 year also most commonly presented with either bacteraemia without focus (37.5%), and pneumonia (31.3%), a higher proportion presented with empyema (25.0% for children aged 1 year compared to 7.4% of children under 1 years). Meningitis was a less common presentation for children aged 1 to 4 years compared to those aged under 1 years.

The majority of those aged 65 years and over (77.5%) presented with pneumonia.

Over half of the cases (15 out 26, 57.7%) who presented with empyema were infected with serotype 19A. Lower proportions of the other clinical presentations were due to serotype 19A - 14.3% of those presenting with meningitis; 34.1% of those presenting with pneumonia;16.3% of those presenting with bacteraemia without focus, and 8.3%) of those with an 'other' presentation.'.

Table 9. Clinical presentation of invasive pneumococcal disease cases by age group, 2021

Age group (years)	Meningitis		Empyema		Pneumonia		Bacteraemia without focus		Other[c]		Total[d]
	Cases[a]	%[b]	Cases[a]	%[b]	Cases[a]	%[b]	Cases[a]	%[b]	Cases[a]	%[b]	
<1	4	14.8	2	7.4	9	33.3	11	40.7	1	3.7	27
1	1	6.3	4	25.0	5	31.3	6	37.5	0	0.0	16
2–4	1	4.5	8	36.4	7	31.8	6	27.3	0	0.0	22
5–64	17	7.8	9	4.1	140	63.9	47	21.5	6	2.7	219
≥65	5	2.7	3	1.6	141	77.5	28	15.4	5	2.7	182
Total[e]	**28**	**6.0**	**26**	**5.6**	**302**	**64.8**	**98**	**21.0**	**12**	**2.6**	**466**

[a] Number of cases with 'yes' recorded for the clinical presentation. 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] Other includes septic arthritis
[d] Number of cases with at least one clinical presentation recorded.
[e] At least one clinical presentation was recorded for 466 (99.6%) of cases notified in 2021.

Hospitalisations and fatalities

Information on whether the case was hospitalised was recorded for 459 (98.1%) of the 468 IPD cases notified in 2021. Of these 459 cases, the majority (447;97.4% were hospitalised – this proportion is similar to previous years.

Information on whether the patient survived or died was recorded for 456 (97.4%) of the 468 IPD cases notified in 2021. Overall, 41 (9%) of these cases were reported as having died. IPD recorded as the primary cause of death for 27 of these deaths (a further two had an unknown cause of death and 12 were not attributable) – a case-fatality rate of 5.9%. There were five deaths due to IPD reported in the <5 years age group in 2021, compared to one in 2020, two in 2019 and one in 2017 and in 2018.

RISK FACTORS

The risk factors reported among IPD cases in 2021 which would have made the case eligible for additional funded vaccines are presented in Table 10. Amongst cases for which this information is provided, the risk factors reported for children <5 years of age were being immunocompromised (5.3%, 3 cases) and chronic lung disease (6.6%, 4 cases). Of these cases, two had received at least one PCV13 while the remaining received PCV10 only or were unvaccinated. Of cases ≥5 years of age, 23.2% were reported to be immunocompromised and over 18.4% had chronic lung disease. Four adults were asplenic. Four cases of IPD were reported to have cochlear implants.

Table 10. Conditions reported and associated with highest risk of IPD (2021)**

Risk factor	<2 Years (n= 42)				<5 Years (n = 65)				≥5 Years (n =402)			
	Cases[a]	Total[b]	%[c]	Unknown	Cases[a]	Total[b]	%[c]	Unknown	Cases[a]	Total[b]	%[c]	Unknown
Anatomical or functional asplenia	0	39	0.0	3	0	60	0.0	5	4	368	1.09	34
Chronic Lung disease, including CLD of prematurity	3	40	7.5	2	4	61	6.6	4	70	380	18.4	22
Cochlear Implants	0	40	0.0	2	0	61	0.0	4	4	348	1.1	54
Immunocompromised	0	36	0.0	6	3	57	5.3	8	87	375	23.2	27

[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.
**Entitled to High Risk vaccine schedule as per immunisation handbook 2020

In addition to risk factors that would make an individual eligible for a high-risk vaccine schedule, there are other chronic conditions that are known to be associated with increased risk of IPD including cardiac disease (five cases), alcohol-related disease (two cases), diabetes (38 cases), and chronic liver disease (six cases), all of whom were aged over 5 years.

Other conditions associated with increased risk of IPD include Down Syndrome (no cases) and pre-term birth. In 2021, among cases for which information was recorded, 9.1% (n = 6) of children under 5 years of age and 12.1% (n = 4) of children under 2 years of age were premature.

DISCUSSION

IPD became a notifiable disease in 2008, at the same time a pneumococcal vaccine (PCV7) was introduced into the New Zealand childhood immunisation programme. Further important changes to the vaccine schedule were implemented with PCV10 introduced in 2011 and replaced by PCV13 in 2014. PCV10 was reintroduced into the childhood immunisation schedule in 2017 and PCV13 still available and funded for people at high risk of IPD, including high risk children and adults over 65 years [1]. Adults 65 years or older are also recommended to receive the 23PPV, however this is not funded in this group.

EPIDEMIOLOGY

Total population

The lowest overall annual incidence rate recorded since IPD became a notifiable disease was in 2020, and the second lowest in 2021. Throughout 2020 and 2021, national and global public health measures were implemented to decrease transmission rates for COVID-19. These measures included restrictions on population sizes at gatherings, domestic and international travel restrictions, nation-wide lockdowns, mask wearing and social distancing. In addition to decreasing transmission of SARS-CoV-2, these mitigation measures have contributed to significant reductions of other infectious diseases, such as influenza rates around the world throughout 2020 [25]. Transmission of SARS-CoV-2 and S. pneumoniae occur through airborne droplets therefore measures introduced in response to COVID-19 were also protective against IPD [26, 27]. Our 2020 report demonstrated a correlation between COVID-19 control measures and a reduction in the annual incidence rate of IPD in New Zealand in 2020 [10]. Although the IPD annual incidence rate increased between 2020 and 2021, the ongoing COVID-19 control measures in place at times throughout 2021 have likely contributed to the lower rate than that seen pre-pandemic. The lowest annual incidence rate prior to the pandemic was in 2015.

Age

IPD annual incidence rate trends pre-pandemic in children under 2 years and under5 years are reflective of a direct impact of changes to the PCV immunisation schedule. Between 2009 and 2015, a substantial decline in rates of IPD in these age groups were observed. For children under 5 years, the rate increased in 2016 and remained stable through to 2019, which may have been secondary to the reintroduction of PCV10, replacing PCV13, in 2017. For children under 2 years, the rate increased from 2015–2018 before decreasing slightly in 2019. Rates for both age groups decreased in 2020 but increased again in 2021. Although the lower 2020 rate was likely driven primarily by COVID-19 public health measures, the increase in 2021 reflects the increase of PCV13 serotypes no longer covered in the vaccination schedule. While the total population incidence rate remains below pre-pandemic levels, the incidence rates in the under 5 years age group and under 2 years age group remain highest since 2009 and 2012, respectively.

In the ≥65 years age group there has been nearly a 50% decrease in the annual incidence rate of IPD between 2009 and 2021. Despite an overall decreasing trend for this age group, the annual incidence rate in 2021 was higher than that observed in 2020, likely at least partially the result of delayed indirect effects of changes in the

childhood immunisation schedule as well as COVID-19 public health measures. A systematic review by Shiri, Datta (27) established that obtaining a 50% reduction in IPD in unvaccinated groups is delayed by approximately three years (2.3 years for PCV7 serotypes and 3.6 years for PCV13 serotypes) and almost a decade was required before a 90% reduction in IPD was obtained through herd immunity (8.9 years for PCV7 serotypes and 9.5 years for PCV13 serotypes) [27]. These factors should be considered when evaluating the effectiveness of childhood immunisations on IPD rates in the total population.

Ethnicity, deprivation, and region

Pacific peoples and Māori continue to be disproportionately affected by IPD across all age groups. The highest crude IPD rates were among Māori and Pacific peoples. While between 2020 and 2021, the rates increased for Māori, Asian and European or Other ethnic groups, the IPD rate in Pacific peoples changed very little. Importantly, Māori and Pacific peoples are over-represented in the IPD cases in children <2 years of age, with 59.5% of cases <2 years old with a known ethnicity being Māori or Pacific peoples.

IPD continues to disproportionately affect those residing in areas of high deprivation.

Between 2020 and 2021 an overall increase in rates of IPD was observed in all regions, with substantial increases in rates observed in Hawke's Bay, Nelson Marlborough, Northland, Tairāwhiti and Whanganui. In 2021, the highest rate of IPD was in Tairāwhiti DHB.

Serotype distribution

The most common serotype in 2021 was 19A (PCV13). The proportion of isolates with an available serotype result that are vaccine preventable (PCV13 serotypes) was 41.0%. In 2021, among the additional PCV13 serotypes (3, 6A, and 19A), 19A was the most prevalent serotype (accounting for 52.5% of cases <5 years of age and 26.6% of cases aged ≥5 years), 3 was the fourth most prevalent (accounting for 4.9% of cases <5 years of age and 4.5% of cases in those aged ≥5 years) and 6A remains uncommon in New Zealand, accounting for zero cases. Rates of 19A have increased substantially in children <2 years and 2–4 years whilst relatively modest increases were observed for 5–64 and ≥65 years age groups. Nearly 90% of these children under 5 were fully vaccinated or on schedule for their age, all of whom received at least one dose of PCV10. The re-introduction of PCV10 to the childhood immunisation programme in 2017, replacing PCV13, could explain why those <5 years of age have been disproportionally affected by the increasing incidence of serotype 19A at this time. The delayed indirect effect on unvaccinated populations may also still be contributing to the continued decrease in 19A in older age groups [27].

The second and third most common serotypes in 2021 were 8 and 22F, respectively, which are not covered by any PCV vaccinations but covered under 23PPV. Serotype 8 has shown an overall increasing trend over 2012–2021, particularly in the adult aged 25–64. Serotype 22F has shown an overall decreasing trend but continues to mostly affect adults aged 65 years and over with 18 out of 26 cases reported in this age group.

In several countries, there has been an increase in serotype 19A since the introduction of PCV10 to national immunisation programmes. Surveillance data for serotype 19A recorded in Finland, Brazil and Chile demonstrated an increase in 19A incidence across all age

groups, illustrating limited cross-reactivity and lack of herd immunity [28]. In contrast, introduction of PCV13 to national immunisation programmes lead to significant and sustained decreases in serotype 19A incidence in several countries [28].

Since the replacement of PCV13 with PCV10 in the New Zealand childhood immunisation schedule in 2017, there has been an increase in IPD cases caused by serotype 19A in those <65 years of age. Similar trends have been observed in other countries. For example, during 2015 and 2016 PCV10 replaced PCV13 in Belgium following the National Immunization Technical Advisory Groups (NITAG) rating these two vaccines as equally effective [29]. With the re-introduction of PCV10 there was a 10-fold increase in the number of IPD cases caused by serotype 19A between 2015 and 2017 [29]. When comparing counties in Sweden, there was a 7-fold increase in serotype 19A in counties using PCV10 between 2013 and 2016, while the incidence of 19A remained consistent in counties utilising PCV13 in their childhood immunisation schedule [30]. Among those <5 years of age there were no cases of IPD in this age group in PCV13 counties, compared to an average annual incidence rate of 1.1 per 100,000 cases in counties where PCV10 was utilised [30].

Lee, Nahm (31) established that PCV10 produced antibodies against serotype 19A through cross-reactivity with 19F, however the majority of these antibodies were not sufficiently functional in opsonisation and therefore had minimal efficacy [28, 31]. PCV13 has also been proven to significantly decrease carriage of serotype 19A which would further increase herd immunity [32]. Furthermore, serotype 19A has increased potential to cause invasive disease compared to other *S. pneumoniae* serotypes, however the invasive potential is decreased with the introduction of PCV13 [33]. With the rise in 19A serotype IPD in New Zealand these factors should be taken into account.

CONCLUSION

With the emergence of COVID-19 and associated global and national public health measures, a significant decrease in the overall annual incidence in IPD among all age groups was observed in 2020, and in 2021, the annual incidence rate increased again, but remains lower than in pre-pandemic years. However, the increase in incidence of IPD caused by serotype 19A in 2020 and 2021 demonstrates the resurgence of 19A in the community. Despite recent changes to the immunisation schedule during 2022 [34], 19A should continue to be monitored closely across all age groups, particularly given the invasive potential of serotype 19A, as a number of years may be required to reduce rates across the population (including those not targeted by the new vaccination schedule) once PCV13 has been reinstated.

There is a disproportionate burden of IPD for Māori and Pacific peoples, particularly in children <2 years of age and adults aged 65 years and over, and effort should continue to be made to ensure these communities have high vaccination rates to increase protection against IPD.

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APPENDIX

Table 11. Number and percentage of invasive pneumococcal disease cases by serotype, serotypes covered by PCV7, PCV10 and PCV13, and age group, 2021

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	-	0	-	0	-	2	0.9	1	0.5	3	0.6
6B	0	-	0	-	0	-	0	-	1	0.5	1	0.2
9V	0	-	0	-	0	-	0	-	0	-	0	-
14	0	-	0	-	0	-	1	0.5	1	0.5	2	0.4
18C	0	-	0	-	0	-	1	0.5	1	0.5	2	0.4
19F	0	-	0	-	0	-	2	0.9	8	4.4	10	2.1
23F	0	-	0	-	0	-	0	-	0	-	0	-
PCV7	**0**	**-**	**0**	**-**	**0**	**-**	**6**	**2.7**	**12**	**6.6**	**18**	**3.8**
1	0	-	0	-	0	-	0	-	0	-	0	-
5	0	-	0	-	0	-	0	-	0	-	0	-
7F	1	2.3	0	-	1	1.5	5	2.3	1	0.5	7	1.5
PCV10	**1**	**2.3**	**0**	**-**	**1**	**1.5**	**5**	**2.3**	**1**	**0.5**	**7**	**1.5**
3	3	7.0	0	-	3	4.5	6	2.7	12	6.6	21	4.5
6A	0	-	0	-	0	-	0	-	0	-	0	-
19A	16	37.2	16	69.6	32	48.5	57	26.0	50	27.3	139	29.7
PCV13	**19**	**44.2**	**16**	**69.6**	**35**	**53.0**	**63**	**28.8**	**62**	**33.9**	**160**	**34.2**
6C	1	2.3	2	8.7	3	4.5	9	4.1	6	3.3	18	3.8
7C	0	-	0	-	0	-	2	0.9	1	0.5	3	0.6
8	3	7.0	0	-	3	4.5	55	25.1	20	10.9	78	16.7
9N	1	2.3	0	-	1	1.5	6	2.7	1	0.5	8	1.7
10A	2	4.7	1	4.3	3	4.5	2	0.9	3	1.6	8	1.7
11A	1	2.3	0	-	1	1.5	4	1.8	9	4.9	14	3.0
12F	2	4.7	0	-	2	3.0	9	4.1	3	1.6	14	3.0
13	1	2.3	0	-	1	1.5	0	-	2	1.1	3	0.6
15A	0	-	0	-	0	-	0	-	3	1.6	3	0.6
15B	5	11.6	1	4.3	6	9.1	6	2.7	5	2.7	17	3.6
16F	1	2.3	0	-	1	1.5	9	4.1	9	4.9	19	4.1
17F	0	-	0	-	0	-	1	0.5	1	0.5	2	0.4
20	0	-	0	-	0	-	2	0.9	0	-	2	0.4
21	1	2.3	1	4.3	2	3.0	2	0.9	0	-	4	0.9
22F	1	2.3	0	-	1	1.5	7	3.2	18	9.8	26	5.6
23A	0	-	0	-	0	-	2	0.9	5	2.7	7	1.5
23B	1	2.3	0	-	1	1.5	7	3.2	9	4.9	17	3.6
31	0	-	0	-	0	-	1	0.5	0	-	1	0.2
33F	0	-	0	-	0	-	5	2.3	1	0.5	6	1.3
34	0	-	0	-	0	-	2	0.9	1	0.5	3	0.6
35B	0	-	0	-	0	-	1	0.5	5	2.7	6	1.3
35F	0	-	0	-	0	-	1	0.5	1	0.5	2	0.4
37	0	-	0	-	0	-	0	-	1	0.5	1	0.2
38	0	-	0	-	0	-	1	0.5	0	-	1	0.2
6D	0	-	0	-	0	-	1	0.5	0	-	1	0.2
Other[d]	0	0.0	0	-	0	-	1	0.5	1	0.5	2	0.4
Non-PCV	**20**	**46.5**	**5**	**21.7**	**25**	**37.9**	**136**	**62.1**	**105**	**57.4**	**266**	**56.7**
NA[e]	3	7.0	2	8.7	5	7.6	9	4.1	3	1.6	17	3.6
Total[f]	**43**	**100**	**23**	**100**	**66**	**100**	**219**	**100**	**183**	**100**	**468**	**100**

[a] Aggregated age group.
[b] Among the cases in the ≥65 years age group, 74.3% were due to 23PPV serotypes. Vaccination with 23PPV is recommended for people in this age group.
[c] Percentage of cases within the age group with the serotype.
[d] Includes non-typeable serotypes.

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