ROTAVIRUS IN NEW ZEALAND, 2015

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ABBREVIATIONS

Abbreviation	Description
CI	Confidence interval
DHB	District health board
ED	Emergency department
ESR	Institute of Environmental Science and Research Ltd
HDEC	Health and Disability Ethics Committee
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification
MELAA	Middle Eastern, Latin American or African ethnicity
NHI	National Health Index
NIR	National Immunisation Register
NMDS	National minimum data set (hospital discharges)
nt	not typed
NZDep	New Zealand index of deprivation
PCR	Polymerase chain reaction
RNA	Ribonucleic acid
RT-qPCR	Real-time quantitative reverse transcription PCR
SCL	Southern Community Laboratories

SUMMARY

Rotavirus infections are the most common cause of severe gastroenteritis in young children worldwide. In New Zealand prior to the introduction of a rotavirus vaccine, it was estimated that 1 in 52 children were hospitalised with rotavirus gastroenteritis by 3 years of age [1]. On 1 July 2014, a three-dose schedule of the oral rotavirus vaccine RotaTeq® was added to the national childhood immunisation schedule to be administered at 6 weeks, 3 months and 5 months of age. RotaTeq® is a pentavalent vaccine containing five live reassortant human (in bold) and bovine rotaviruses (**G1**P7[5]; **G2**P7[5]; **G3**P7[5]; **G4**P7[5]; and G6**P1[8]**).

This report presents information on rotavirus infections from a variety of sources, including national hospital discharges and community laboratory testing of gastroenteritis faecal samples pre- and post-vaccine introduction; and sentinel hospital-based surveillance at Kidz First Children's Hospital post-vaccine introduction.

The introduction of rotavirus vaccination in Australia resulted in a 70% decrease in rotavirus hospitalisations in the two and a half years following vaccine introduction [2]. We report a similar decline in NZ in the first year following vaccine introduction where rotavirus hospitalisation rates for children aged under 5 years declined by 85% in 2015 compared with the previous five-year average (2010–2014).

In addition, the community laboratory data support a decrease in rotavirus infections in the community with the number of rotavirus-positive samples decreasing following rotavirus vaccine introduction. The proportion of all gastroenteritis faecal samples that were positive for rotavirus decreased from a peak of 12–14% pre-vaccine to less than 3% following vaccine introduction.

Rotavirus surveillance is important to determine if variability in genotypes is due to secular trends or whether vaccine pressure results in selection of certain genotypes. G12P[8] was the predominant (47.5%) rotavirus genotype detected in 2015. Three rotaviruses, G1P[not typed], G1P[8] and GntP[8] were identified as vaccine-like and were all from partially immunised children.

Although no formal evaluation of the rotavirus screening tests used in New Zealand was performed, the diagnostic procedures used by New Zealand laboratories do vary. At least three different assays were used by laboratories participating in the non-sentinel surveillance component of the study.

There has been a significant decrease in rotavirus infections and in rotavirus as a proportion of all gastroenteritis. Surveillance of rotavirus hospitalisations through sentinel surveillance sites, review of national hospitalisation data, and laboratory genotyping will be continued to monitor trends of severe rotavirus infection and vaccine selection pressure on rotavirus genotypes. This will be important as New Zealand moves to a two dose rotavirus vaccine schedule in 2017 to ensure adequate protection against severe rotavirus infections remains.

INTRODUCTION

Rotavirus infections are the most common cause of severe gastroenteritis in young children worldwide. Compared with illness caused by other enteric pathogens, the diarrhoea due to rotavirus is particularly severe and often associated with vomiting and dehydration. In New Zealand prior to the introduction of a rotavirus vaccination it was estimated that 1 in 52 children were hospitalised with rotavirus gastroenteritis by 3 years of age [1]. Rotavirus infections peak in the second year of life and during winter and spring.

The rotavirus vaccine RotaTeq® was added to the childhood immunisation schedule on 1 July 2014, and is administered orally at 6 weeks, 3 months and 5 months of age. Older children are more likely to have been exposed to rotavirus already, and therefore less likely to benefit from vaccination [3].

Rotavirus is not a notifiable disease in New Zealand. Various reports and studies have been conducted that describe the epidemiology of severe gastroenteritis and rotavirus hospitalisations in New Zealand pre-vaccine introduction. The introduction of rotavirus vaccination in Australia resulted in a 70% decrease in rotavirus hospitalisations [2]. We would expect a similar decrease in rotavirus gastroenteritis hospitalisations in New Zealand.

Sentinel hospital-based rotavirus surveillance was established in mid-December 2014 at Kidz First Children's Hospital in Counties Manukau District Health Board (DHB), with the first year of surveillance described in this report. The hospital surveillance was extended to Wellington, Hutt and Christchurch Hospitals in April 2016. The aim of this surveillance is to monitor the impact of the vaccination programme on rotavirus hospitalisations and on the viral genotypes in children aged under 5 years.

This report presents a summary from published reports and studies on rotavirus epidemiology in New Zealand prior to the rotavirus vaccine introduction. We then present information on rotavirus from a variety of sources, including national hospital discharges and community laboratory testing pre- and post-vaccine introduction; and sentinel hospital-based surveillance at Kidz First Children's Hospital post-vaccine introduction.

METHODS

SURVEILLANCE METHODS

The following is an excerpt from the rotavirus chapter of the Centers for Disease Control and Prevention Manual for the Surveillance of Vaccine-Preventable Diseases [4]. The excerpt outlines the purpose of surveillance for rotavirus infections after the introduction of rotavirus vaccination into a national childhood immunisation schedule.

"With the introduction of a new rotavirus vaccine into the childhood immunisation programme, conducting surveillance is important in order to:

- monitor the impact of vaccination in reducing the morbidity and mortality from rotavirus disease;
- evaluate vaccine effectiveness in field use and identify and determine the causes of possible vaccine failure;
- monitor the possible emergence of rotavirus strains that might escape vaccination;
- identify population groups that might not be adequately covered by vaccination; and
- continue to monitor the safety of rotavirus vaccines.

As nearly every child suffers from rotavirus gastroenteritis by 5 years of age, identification of every case of rotavirus through laboratory testing of faecal specimens is not practical or necessary. Surveillance efforts should focus on monitoring trends of severe rotavirus disease such as rotavirus hospitalisations at the national level and through more intensive efforts at some sentinel sites. In addition to severe disease surveillance, viral strain surveillance is also important to evaluate whether strain variability is a secular phenomenon or whether it is the result of a potential selection of rotavirus genotypes through vaccine pressures [4]."

National hospital discharges

The Ministry of Health collates national data on public and private hospital discharges. These data are stored as part of the National Minimum Dataset (NMDS). Anonymised records with a principal diagnosis of intestinal infectious disease (ICD-10-AM diagnosis codes A00–A09), including a rotavirus-specific code of A08.0 rotaviral enteritis, and a discharge date in 2010–2015 were extracted for children aged 0–4 years. Records were extracted from the NMDS on 11 March 2016. Records were excluded if the case was a New Zealand non-resident.

From July 2012, the NMDS data include all short stay emergency department (ED) events (events where admitted patients are discharged under an ED specialty after a length of stay of less than two days). Prior to July 2012, DHBs had differing admission practices resulting in differences in the data reported, therefore the data may not be comparable for the whole 2010–2015 period [5].

Sentinel hospital-based surveillance

Surveillance for rotavirus hospitalisation was implemented at Kidz First Children's Hospital, starting with a pilot phase from 12 December 2014. The medical records of all children aged under 5 years with acute gastroenteritis admitted to a ward (inpatient) or present in the ED were reviewed. Faecal samples were collected from children meeting the case definition for acute diarrhoea and were sent to the Middlemore Hospital laboratory for screening for rotavirus. Any positive samples were then referred to the Institute of Environmental Science and Research (ESR) for typing.

Verbal consent was requested from parents / caregivers. Ethics approval was sought from the Health and Disability Ethics Committee (HDEC), however the surveillance activity was not considered to be within the scope of HDEC review and therefore approval was not required (HDEC reference: 14/CEN/209).

The following case definition was used to identify cases of acute diarrhoea:

> *>3 liquid stools in a 24-hour period of <10 days duration where, on admission, no alternative explanation exists*.

Children who developed diarrhoea while in hospital (up to three days after hospitalisation) were excluded. Children who were readmitted, or seen in ED again, within 14 days with gastrointestinal illness were excluded for their second visit.

A case report form covering demographic and clinical information (see appendix) was completed for each eligible child and entered into REDCap. REDCap is a free, secure, web-based application designed to support data capture for research studies. The data presented in this report are based on information recorded in REDCap as at 10 June 2016. Any changes made after this date are not reflected in this report. Laboratory results were matched with case data.

Immunisation status and coverage

Immunisation status is based on data from the National Immunisation Register (NIR). The National Health Index (NHI) numbers for laboratory-confirmed rotavirus cases were provided to the Ministry of Health and matched with rotavirus immunisation records, including the number of doses given and the date each does was received.

Rotavirus immunisation national coverage reports were obtained from the Ministry of Health for the final quarter of 2014 and each quarter in 2015.

Community and hospital laboratory surveillance

We obtained community and hospital laboratory data on the number of faecal samples submitted for microbiological investigation and the number that were positive for rotavirus from January 2010 to December 2015. Anonymised data were obtained from Labtests NZ (covering the Auckland and Northland regions) and Southern Community Laboratories (SCL) (covering Southern, South Canterbury, Canterbury and Nelson-Marlborough DHBs, and

Hawke's Bay and Taupo regions). Labtests NZ carry out testing of samples from community-based patients only, whereas SCL covers both community and hospital-based patients, apart from Hawke's Bay and Canterbury which are community-based only.

Labtests NZ stopped routine testing for rotavirus on 2 November 2015. Prior to this, all faecal samples for children aged 3 years and under were routinely tested for rotavirus. After this date, testing was only carried out if specifically requested. SCL routinely tests all faecal samples for rotavirus for children aged 3–5 years or younger[1], and by request for all other ages.

Tests used to detect rotavirus vary by laboratory and are shown below in Table 1.

Table 1. Tests used to detect rotavirus at Labtests NZ and SCL

Laboratory	Diagnostic kit	Manufacturer
Labtests NZ	Rotascreen II ® EIA	Microgen Bioproducts
SCL Hawke's Bay	Rota-Strip	Coris BioConcept
SCL Nelson-Marlborough	GastroVir (Rotavirus/Adenovirus 40/41 combination)	Coris BioConcept
SCL Canterbury	Immuno*Card* STAT!® Rotavirus	Meridian Bioscience
SCL South Canterbury	CerTest Rotavirus + Adenovirus	CerTest Biotec
SCL Dunedin (includes Taupo and Oamaru)	Rota-Strip	Coris BioConcept
SCL Southland	Immuno*Card* STAT!® Rotavirus	Meridian Bioscience

LABORATORY METHODS

Rotavirus screening

Faecal samples from the sentinel hospital-based surveillance site (Kidz First Children's Hospital, Counties Manukau DHB) were screened at the Middlemore Hospital laboratory. Samples were screened for rotavirus antigen using a lateral flow immunoassay, initially with RIDA®QUICK Rotavirus/Adenovirus Combi and later with Coris BioConcept GastroVir performed in parallel. If results were discrepant, the result was reported as indeterminate. Positive and indeterminate samples were sent to ESR for genotyping.

In August 2015, a request was made to New Zealand laboratories to submit rotavirus-positive faecal samples to ESR regardless of the age of the patient. This was to aid in establishing the rotavirus typing procedure and developing the testing algorithm at ESR. It also enabled the detection of more genotypes. Demographic information was not requested for these samples, other than age and sex for sample identification purposes. Methods of rotavirus antigen screening varied by laboratory.

[1] Age cut-off varies by laboratory: Christchurch, Southland <3 years; Hawke's Bay <3.5 years; Dunedin, Oamaru, Taupo <4 years; South Canterbury, Nelson-Marlborough <5 years.

Confirmation of the screening result was undertaken by ESR using real-time quantitative reverse transcription polymerase chain reaction (RT-qPCR).

Genotyping

Samples confirmed as positive for rotavirus by RT-qPCR by ESR were genotyped according to the G and P typing system [6].

Details on the methods used can be found in the appendix.

LITERATURE REVIEW

A search was performed using PubMed, Google Scholar and grey literature, to identify studies or reports describing the epidemiology of rotavirus infection prior to the availability of a rotavirus vaccine in New Zealand. Search terms used were ((rotavirus) AND New Zealand) AND human. Query translation: (("rotavirus"[MeSH Terms] OR "rotavirus"[All Fields]) AND ("new zealand"[MeSH Terms] OR ("new"[All Fields] AND "zealand"[All Fields]) OR "new zealand"[All Fields])) AND ("humans"[MeSH Terms] OR "humans"[All Fields] OR "human"[All Fields]).

Through PubMed 53 articles were found, of which four described national rotavirus rates in New Zealand. An additional report was found by searching the grey literature. Age-specific annual rates per 100,000 population of hospitalised gastroenteritis and rotavirus were extracted where possible.

A further search for rotavirus genotypes in New Zealand prior to vaccine introduction was conducted using search terms (((rotavirus) AND New Zealand) AND genotypes). Through PubMed four articles were found, of which one described human rotavirus infections and three described bovine rotavirus infection in New Zealand.

ANALYTICAL METHODS

Sentinel hospital-based surveillance

Cases of gastroenteritis that were recorded on the case report form in REDCap were matched with Middlemore Hospital laboratory screening data by the hospital visit number (encounter number). Any cases that were readmitted with gastroenteritis within 14 days were only included once in the dataset. Duplicate laboratory tests were excluded, after confirming that the rotavirus screening test results were the same for both records. This combined dataset was then matched with the genotyping results from ESR.

Population rate calculations

The denominators used to calculate rates, except those used to determine disease rates for ethnic groups, were derived from the 2014 mid-year population estimates published by Statistics New Zealand. Denominators used to determine disease rates for ethnic groups are based on the proportion of children aged under 5 years in each ethnic group from the 2013

Census ‘usually resident population’ applied to the relevant mid-year (2010–2015) population estimates from Statistics New Zealand.

Rates were not calculated where a category had fewer than five cases. Calculating population rates from fewer than five cases produces unstable rates.

Ethnicity

Ethnicity was prioritised in the following order: Māori, Pacific peoples, Asian, Middle Eastern/Latin American/African (MELAA), European or Other (including New Zealander) ethnic groups, as per the Ministry of Health protocol [7].

New Zealand index of deprivation

Socio-economic deprivation was assigned using the 2013 New Zealand index of deprivation (NZDep2013). The NZDep 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 [8]. The deprivation score is calculated for each geographical mesh block in New Zealand.

Statistical significance

Fisher's exact tests were used to determine statistical significance. Results were considered to be statistically significant when the *P* value was less than or equal to 0.05.

RESULTS

ROTAVIRUS EPIDEMIOLOGY IN NEW ZEALAND PRIOR TO VACCINE INTRODUCTION

Four published articles and one report that described rotavirus age-specific rates or national annual rates per 100,000 were found. Information on the rates reported in each is shown in Table 2.

Table 2. Gastroenteritis and rotavirus hospitalisations in New Zealand prior to vaccine introduction

Author	Study location	Age	Year	Estimated annual rate per 100,000 of gastroenteritis (95% CI[1])	Estimated annual rate per 100,000 of rotavirus (95% CI[1])
Ardern-Holmes *et al.*, 1999 [9]	Starship Children's Hospital (Auckland); Middlemore Hospital (South Auckland); Waikato Hospital (Hamilton); Christchurch Hospital (Christchurch)	<5 years	1994–1996	1047	315–362
Grimwood *et al.*, 2006 [1]	New Zealand	<3 years	May1988–April 2000	1452	634–657
		<5 years	May1988–April 2000		416[2]
Neuwelt and Simmons, 2006 [10]	Auckland region case series severe gastroenteritis children under 5 years	<5 years	July–December 2005	239 (196–281)	146 (123–179)
	Auckland region estimated gastroenteritis hospitalisations	<5 years	July–December 2005	1528 (6.4 multiplication factor)[3]	
Milne and Grimwood, 2009 [11]	New Zealand	<5 years	2009[4]		476 (451–502) (hospitalisations) 4,655 (total hospitalisations and ED and primary care)
Craig *et al.*, 2013 [12]	New Zealand	<15 years	2006–2010	604	

[1] Confidence interval
[2] Extrapolated from study data
[3] Estimated from NMDS hospital discharge data for the same six-month period for the Auckland region
[4] Estimated from hospitalisation data July 2003 to June 2006.

ROTAVIRUS GENOTYPE DIVERSITY IN NEW ZEALAND PRIOR TO VACCINE INTRODUCTION

Only one publication on human rotavirus genotypes in New Zealand prior to vaccine introduction was found. This publication reported on one year only (June 2005–May 2006) and was based on children seen at hospital and seeking care in the community from centres throughout New Zealand [13]. Rotavirus types vary from year to year so the following data do not represent the pre-vaccine rotavirus circulating types in New Zealand just prior to the introduction of the vaccine in 2014. Table 3 is adapted from Chandrahasen *et al.* [13] and shows that the main circulating rotavirus G-type during 2005/06 was G1 (64.6%), followed by G4 (24.8%), G3 (3.9%), G9 (3.9%), G2 (1.1%), and detection of mixed types (1.2%). A difference was reported in circulating types between the North and South Islands with G1 predominating in the North Island and G4 predominating, followed by G1, in the South Island. The P-type was only determined for selected rotaviruses and most samples tested were P[8].

Table 3. Rotavirus G-types identified in New Zealand in children aged under 5 years, June 2005–May 2006

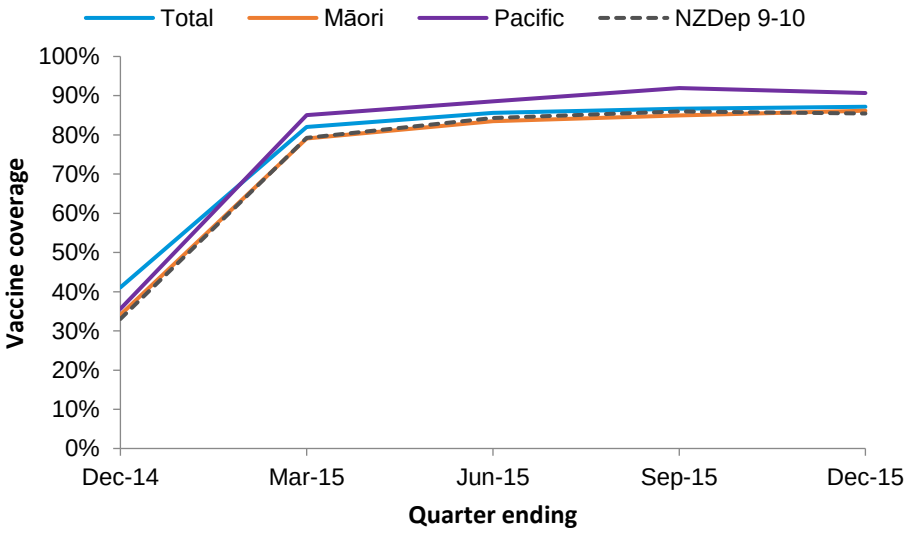
	Total		North Island		South Island	
G-type	Number	Percent	Number	Percent	Number	Percent
G1	232	64.6	159	92.4	73	39.0
G4	89	24.8	1	0.6	88	47.1
G3	14	3.9	3	1.7	11	5.9
G9	14	3.9	3	1.7	11	5.9
G2	4	1.1	4	2.3	0	0.0
G6	1	0.3	0	0.0	1	0.5
G8	1	0.3	0	0.0	1	0.5
Mixed G1/G4	2	0.6	0	0.0	2	1.1
Mixed G1/G2	1	0.3	1	0.6	0	0.0
Mixed G1/G3	1	0.3	1	0.6	0	0.0
Total	**359**	**100.0**	**172**	**100.0**	**187**	**100.0**

Adapted from Chandrahasen *et al.* [13]

ROTAVIRUS VACCINE COVERAGE

The national immunisation coverage report measures the proportion of children who turned the milestone age of 8 months in each quarter and who have completed their age-appropriate rotavirus immunisations by the time they turned the milestone age. As at December 2015, 87.2% of children aged 8 months were fully immunised against rotavirus (Figure 1, Table 13 in the appendix). For Māori the proportion was 86.2%, and for Pacific this was 90.7%. For children living in NZDep2013 deciles 9 and 10 the proportion fully immunised was 85.4%.

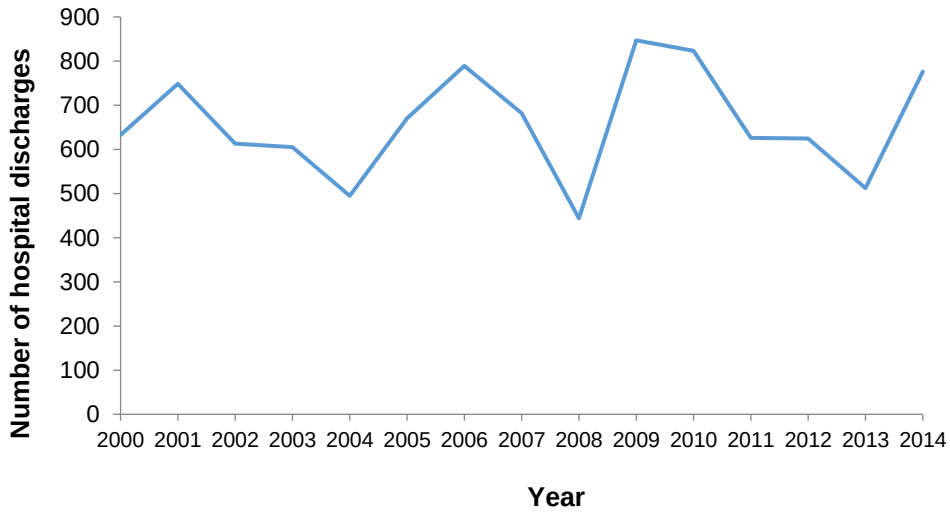
Figure 1. Rotavirus immunisation coverage at age 8 months by quarter, September 2014–December 2015



NATIONAL HOSPITAL DISCHARGES

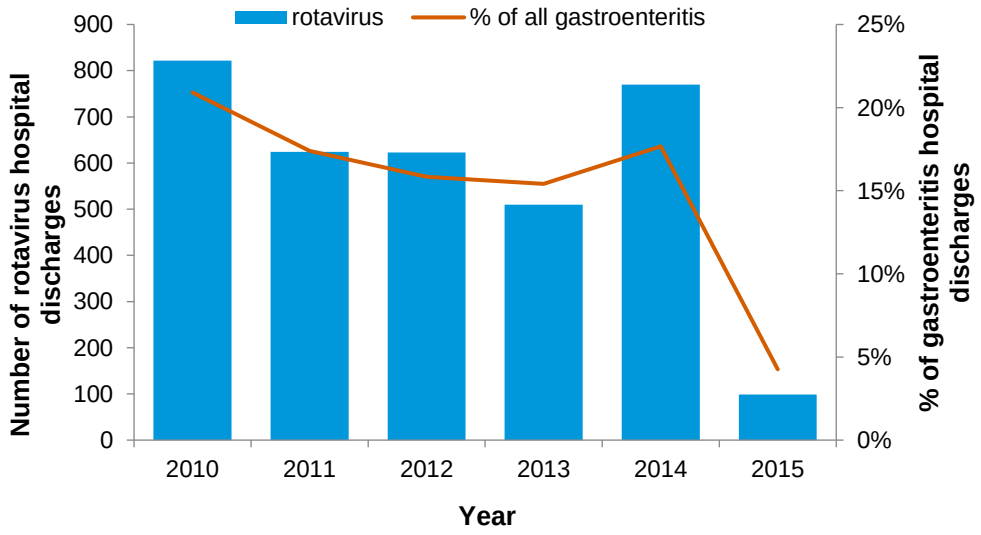
Annual rotavirus hospital discharges for children aged under 5 years followed a cyclical pattern prior to the introduction of the vaccine, with peak years in 2001, 2006, 2009 and 2014 (Figure 2). The rotavirus vaccine was introduced to the New Zealand childhood immunisation schedule on 1 July 2014 with no catch-up campaign.

Figure 2. Rotavirus hospital discharges for children aged under 5 years, all New Zealand, 2000–2014



Hospital discharges for rotavirus ranged from 510 to 822 cases per year in the four years prior to vaccine introduction (2010–2013). There were 99 hospital discharges for rotavirus in children aged under 5 years in New Zealand in 2015, compared with 770 in 2014 (Figure 3).

Figure 3. Rotavirus hospital discharges and as a percentage of all gastroenteritis discharges for children aged under 5 years, all New Zealand, 2010–2015



The hospital discharge rates for children aged under 5 years for gastroenteritis and rotavirus both show a marked decline in 2015, with the gastroenteritis rate being almost half the rate

in 2014 while the 2015 rotavirus rate was only 1/8 the rate seen in 2014 (Table 4). Rotavirus accounted for only 4.3% of gastroenteritis hospital discharges in 2015 compared with an average of 17.4% for 2010–2014.

Table 4. Gastroenteritis and rotavirus hospital discharge rates for children aged under 5 years, all New Zealand, 2010–2015

Year	Gastroenteritis		Rotavirus		Percent[2]
	Number	Rate[1]	Number	Rate[1]	
2010	3931	1260.0	822	263.5	20.9
2011	3589	1142.0	624	198.6	17.4
2012	3934	1261.5	623	199.8	15.8
2013	3311	1075.9	510	165.7	15.4
2014	4361	1412.7	770	249.4	17.7
2015	2325	760.4	99	32.4	4.3

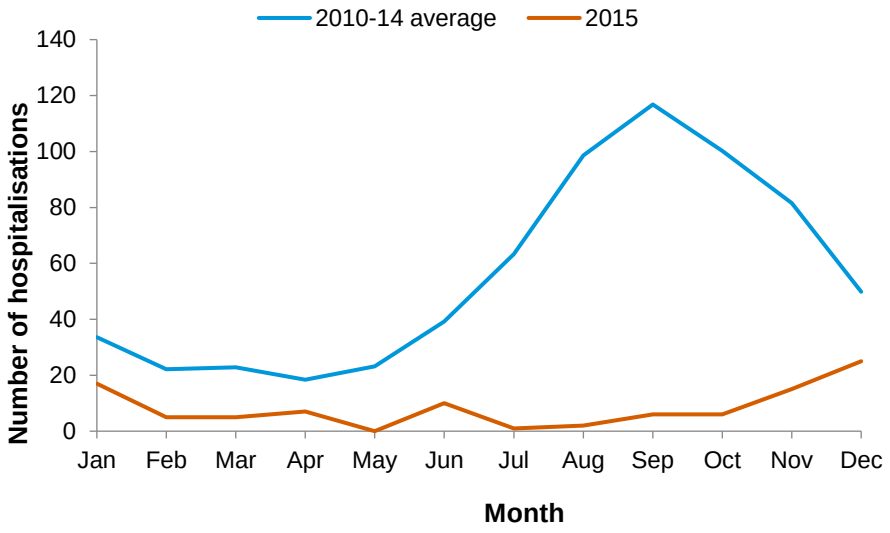
[1] Rate per 100,000 population

[2] Rotavirus as a percent of gastroenteritis hospital discharges

Monthly distribution

The usual seasonal peak for rotavirus hospitalisations for children aged under 5 years occurs around September each year. In 2015, there was no distinct peak in hospitalisations, although there was a later increase in December (Figure 4).

Figure 4. Rotavirus hospital discharges for children aged under 5 years by month, all New Zealand, 2010–2014 average compared with 2015



Age distribution

Of the 99 rotavirus hospitalisations for children aged under 5 years in 2015, 62.6% were male and 37.4% were female. Over a third (35.4%) of hospitalised cases were aged 2–4 years and would not have been eligible to receive rotavirus vaccine, along with some of those aged 1 year and under (Table 5).

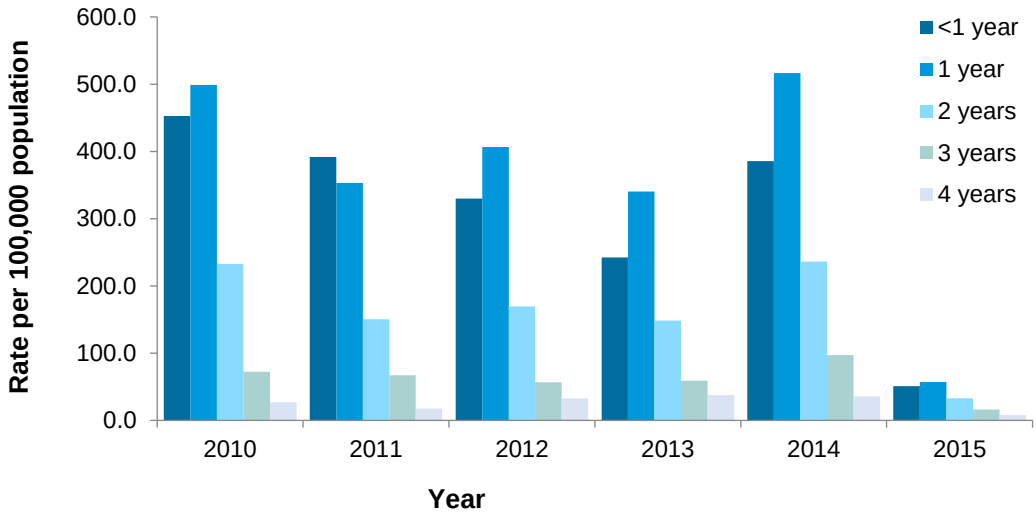
Table 5. Rotavirus hospital discharges for children aged under 5 years by age and sex, all New Zealand, 2015

Age	Female	Male	Total	Percent[1]
<1 year	11	19	30	30.3
1 year	15	19	34	34.3
2 years	7	13	20	20.2
3 years	1	9	10	10.1
4 years	3	2	5	5.1
Total	**37**	**62**	**99**	**100.0**

[1] Percent of the total number of rotavirus hospitalisations

Figure 5 (see also Table 14 in the appendix) shows rates of rotavirus hospitalisations for children aged under 5 years by age and year for 2010–2015. The incidence is highest in the first two years of life and then rapidly decreases. By the time of the rotavirus season (winter/spring) in 2015, children aged under 1 year would have been eligible for free vaccination. A marked decrease was seen in all ages in 2015.

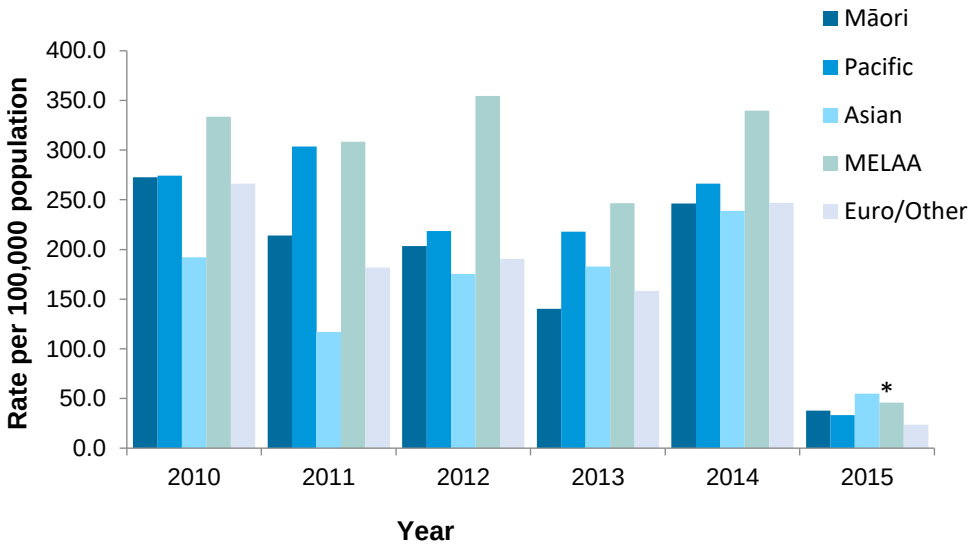
Figure 5. Rotavirus hospital discharge rates for children aged under 5 years by age and year, all New Zealand, 2010–2015



Ethnic distribution

The highest rotavirus hospitalisation rates for children aged under 5 years occurred in the MELAA ethnic group followed by Pacific and then Māori for most years in 2010–2014, except for 2013 (Figure 6). However, the numbers are much lower for MELAA than for other ethnic groups (Table 15 in the appendix). In 2015 the highest rate was in Asian children (54.8 per 100,000). A substantial reduction was seen in all ethnic groups in 2015.

Figure 6. Rotavirus hospital discharge rates for children aged under 5 years by ethnicity and year, all New Zealand, 2010–2015

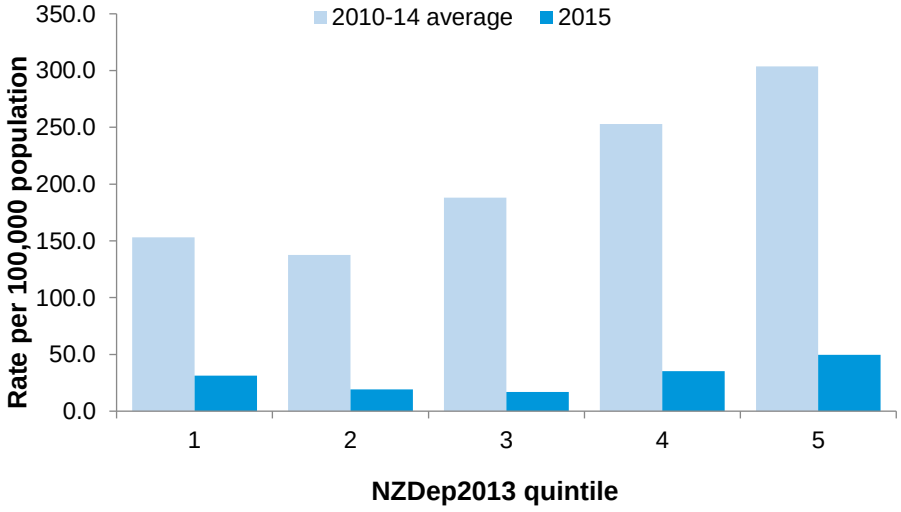


MELAA = Middle Eastern/Latin American/African
* Rate based on less than five cases

Socioeconomic distribution

The highest rates of rotavirus hospitalisation for children aged under 5 years were from the most socioeconomically deprived areas, quintiles 4 and 5 (Figure 7). For 2010–2014 there was a statistically significant difference between NZDep2013 quintile 1 and quintiles 4 and 5 ($p<0.01$) (Table 16 in the appendix). Although a similar pattern was seen in 2015, the differences were not statistically significant.

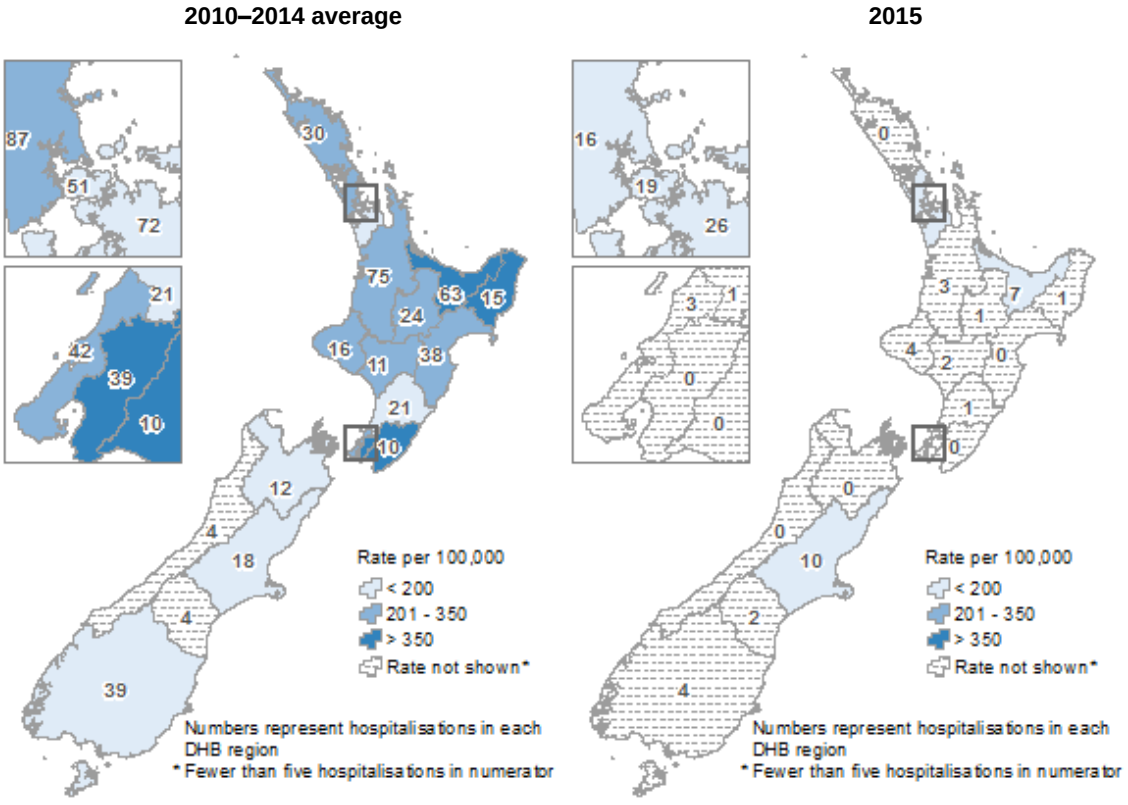
Figure 7. Rotavirus hospital discharge rates for children aged under 5 years by socioeconomic deprivation, all New Zealand, 2010–2014 average compared with 2015



Geographic distribution

There was a dramatic decrease in the rate of rotavirus hospital discharges in 2015 compared with the average for 2010–2014 across all DHBs (Figure 8, Table 17 in the appendix). For 2010–2014 the highest rates were seen in Bay of Plenty, Tairawhiti and Hutt Valley DHBs, while in 2015 the highest rates were in Auckland, Counties Manukau and Bay of Plenty DHBs.

Figure 8. Rotavirus hospital discharge rates for children aged under 5 years by DHB, 2010–2014 average compared with 2015



SENTINEL HOSPITAL-BASED SURVEILLANCE

From 12 December 2014 to 31 December 2015, 592 cases of gastroenteritis in children aged under 5 years were detected through hospital-based surveillance at Kidz First Children's Hospital in Counties Manukau DHB. Verbal consent was obtained for almost all (588, 99.3%) cases and a specimen was taken from 162 (27.6%) of those who consented. The main reason for being unable to obtain a sample was due to the child having no further diarrhoea while they were in hospital (82.4%). Other reasons were ward staff forgetting to collect a sample (9.4%) and being unable to get a sample (6.3%) e.g. due to watery diarrhoea.

The incidence rate for gastroenteritis in children under 5 years at Kidz First Children's Hospital for the period 12 December 2014–31 December 2015 was 1419.7 per 100,000 population. Fifteen cases were hospitalised for gastroenteritis more than once during the study period. An additional 10 gastroenteritis cases readmitted within 14 days were excluded from the analysis.

Laboratory screening

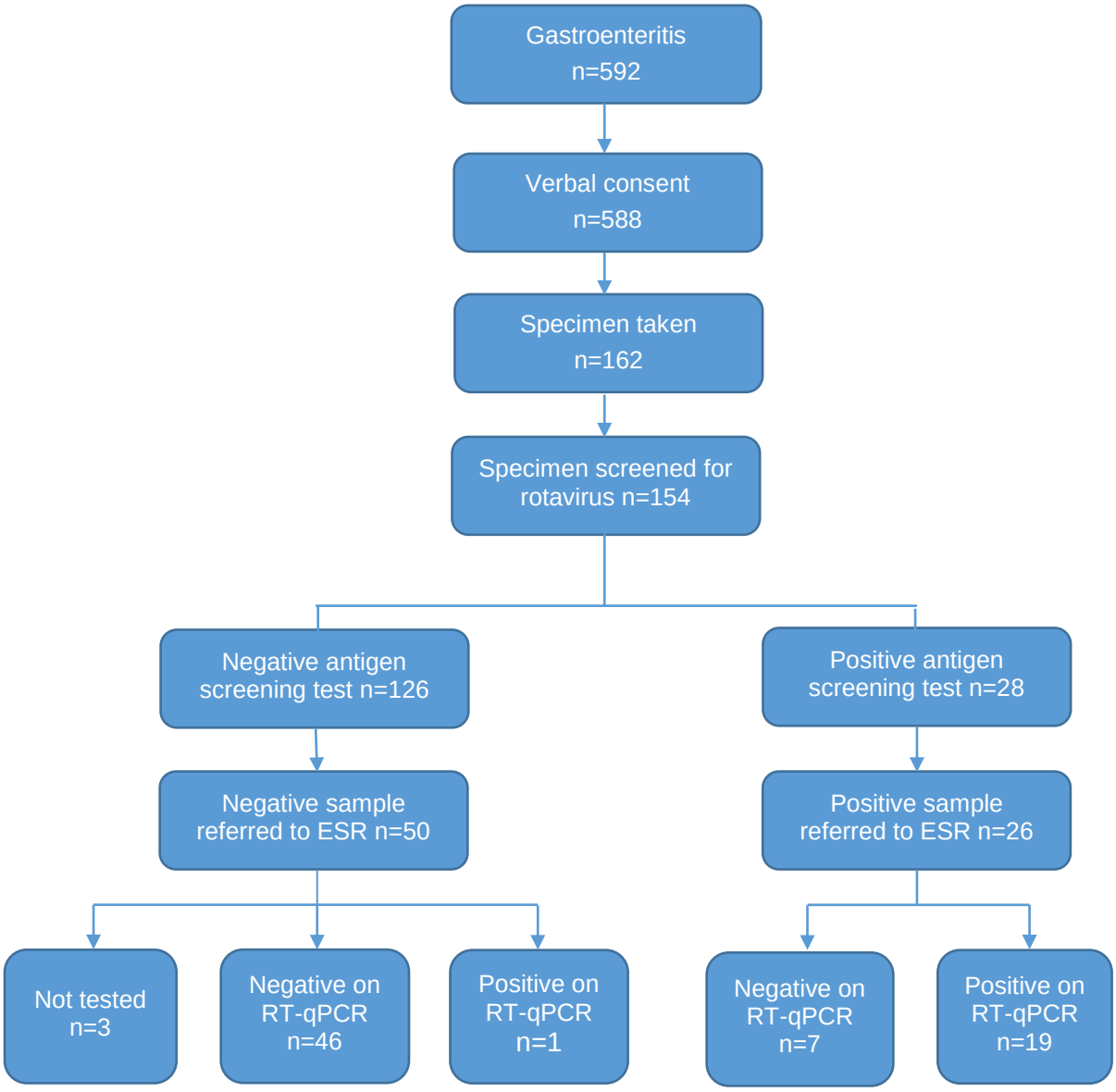
Of the 162 gastroenteritis cases where a specimen was taken, 154 (95.1%) were screened for rotavirus at the Middlemore Hospital laboratory and 28 (18.2%) tested positive for rotavirus antigen. A total of 26 (92.9%) rotavirus-positive samples were referred to ESR for confirmation and genotyping and 19 (73.1%) were positive for rotavirus using RT-qPCR. Seven (26.9%) rotavirus antigen-positive samples from Middlemore Hospital laboratory between December 2014 and June 2015 were negative using RT-qPCR. In August 2015 an additional antigen test, Coris BioConcept GastroVir, was introduced in conjunction with the RIDA®QUICK assay for screening at Middlemore Hospital laboratory and both tests were performed in parallel. If results were discrepant, the result was reported as indeterminate. Positive and indeterminate samples were sent to ESR.

During the pilot stage of the hospital-based surveillance, Middlemore Hospital laboratory selected a sample of 50 faecal specimens that had screened negative for rotavirus and sent them to ESR for confirmation. Of the 47 negative samples that were able to be tested by RT-qPCR at ESR, 46 (97.9%) were confirmed negative, while one (2.1%) was positive for rotavirus.

The proportion of gastroenteritis specimens that were screened antigen-positive and confirmed as rotavirus using RT-qPCR was 12.3% (19/154). Figure 9 shows the number of gastroenteritis cases that were detected, screened and confirmed positive by RT-qPCR from the sentinel hospital-based surveillance.

Notwithstanding the small number of positive samples, the rest of this section describes the 19 cases that were screened antigen-positive and then confirmed as rotavirus positive by RT-qPCR at ESR.

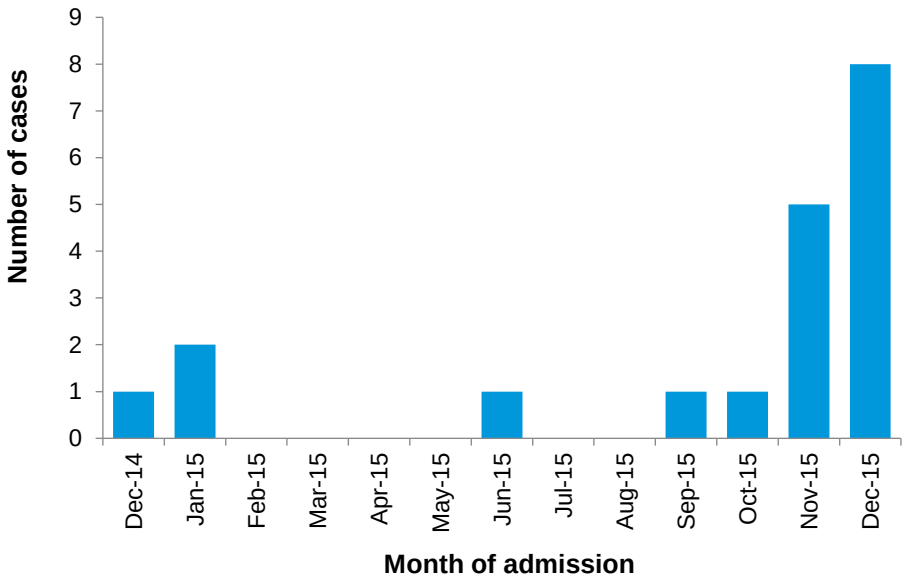
Figure 9. Rotavirus case detection flow diagram for children aged under 5 years, Kidz First Children's Hospital, 12 December 2014–31 December 2015



Incidence by month

Two thirds (13/19, 68.4%) of the confirmed rotavirus cases occurred in November and December 2015 (Figure 10) supporting the late peak seen in the national hospital discharge data (Figure 4).

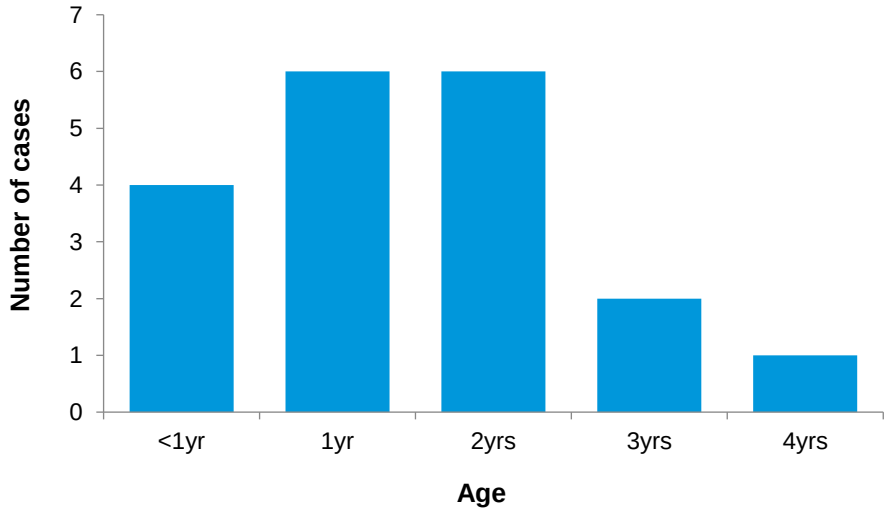
Figure 10. Number of confirmed rotavirus cases for children aged under 5 years by month of admission, Kidz First Children's Hospital, 12 December 2014–31 December 2015



Incidence by age

The highest number of confirmed rotavirus cases occurred in children aged 1 and 2 years (Figure 11, Table 18 in the appendix).

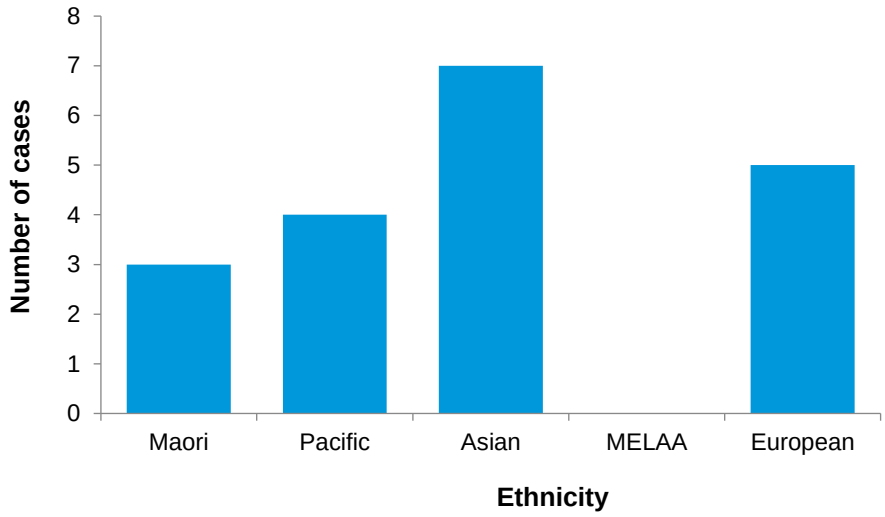
Figure 11. Number of confirmed rotavirus cases for children aged under 5 years by age, Kidz First Children's Hospital, 12 December 2014–31 December 2015



Incidence by ethnicity

The ethnic group with the highest number of confirmed rotavirus cases was Asian (5 Indian, 1 South East Asian and 1 other Asian). (Figure 12, Table 19 in the appendix).

Figure 12. Number of confirmed rotavirus cases for children aged under 5 years by ethnicity, Kidz First Children's Hospital, 12 December 2014–31 December 2015



Incidence by deprivation

The majority (16/19, 84.2%) of confirmed rotavirus cases were from the most socioeconomically deprived areas, NZDep2013 quintile 5 (Table 20 in the appendix).

Disease presentation

The median length of stay was longer for confirmed rotavirus cases than for rotavirus-negative gastroenteritis cases in children under 5 years; 22.3 compared with 9.1 hours (Table 6), however this difference was not statistically significant.

Table 6. Median and range of duration of hospital stay for rotavirus for children aged under 5 years, Kidz First Children's Hospital, 12 December 2014–31 December 2015

Disease	Median	Range	95% CI
Rotavirus (n=19)	22.3 hours	1.3 hours – 7 days	11.0–48.1hours
Rotavirus-negative gastroenteritis (n=133)	9.1 hours	0.8 hours – 12 days	5.8–15.5 hours

Confirmed rotavirus cases were significantly ($p<0.05$) more likely to have moderate dehydration and to have a lower sodium reading (<135 mmol/L) than rotavirus-negative cases (Table 21 in the appendix). They were also more likely to be admitted to a ward, have bloods collected, nasogastric intubation, IV fluid replacement, and febrile seizures. No rotavirus cases were admitted to an intensive care unit or transferred to another hospital.

Immunisation status

The majority of confirmed rotavirus cases (14/19, 73.7%) were not eligible for immunisation given their age at the time that the vaccine was introduced (Table 7). Only one child who was eligible had not been immunised with the appropriate number of doses for their age. Two (10.5%) of the confirmed rotavirus cases were fully immunised with three doses of RotaTeq® prior to hospitalisation, one aged 11 months and one aged 1 year. Two other cases aged under 6 months were partially immunised; one with one dose and one with two doses. The remaining 15 (78.9%) cases had not received any doses of RotaTeq®.

Table 7. Number of doses of rotavirus vaccine received by children aged under 5 years hospitalised with rotavirus, Kidz First Children's Hospital, 12 December 2014–31 December 2015

Number of doses eligible for	Number of doses received				Total
	1	2	3	0	
1	1	0	0	0	1
2	0	1	0	0	1
3	0	0	2	1	3
Not eligible	0	0	0	14	14
Total	**1**	**1**	**2**	**15**	**19**

Distribution by genotype

All 19 samples confirmed as rotavirus positive by RT-qPCR were genotyped. Analysis of G and P genotyping identified G12P[8] as the predominant (9/19, 47.4%) genotype. Vaccine-like rotavirus was identified in one sample, from a child that had received one dose of RotaTeq® (Table 8).

Table 8. Genotype distribution. Kidz First Children's Hospital, 12 December 2014–31 December 2015

Genotype	Number	Percent
G1P[8]	4	21.1
G9P[8]	4	21.1
G12P[8]	9	47.4
GntP[8][1]	1	4.5
G1P[8] vaccine-like	1	5.3
Total	**19**	**100.0**

[1] nt not typed

NON-SENTINEL LABORATORY SURVEILLANCE

Several New Zealand laboratories submitted faecal samples to ESR that tested positive for rotavirus by the laboratory's screening assay. During the time period from mid-December 2014 to December 2015, 57 samples were received by ESR that were not included in the sentinel hospital-based surveillance at Kidz First Children's Hospital. Samples were from people of all ages, although most (41/57, 71.9%) were from children aged under 5 years. Of the 57 samples received, 55 were tested for rotavirus using RT-qPCR (as insufficient sample was available for testing for two samples) and 37 (67.3%) samples tested positive. The contributing laboratories and the number of submitted samples confirmed by RT-qPCR are shown in Table 9.

Table 9. Rotavirus-positive samples submitted to ESR for typing, December 2014–December 2015

Submitting laboratory	Number of samples received	Samples tested by RT-qPCR[1]	Rotavirus positive by RT-qPCR	Percent confirmed positive
Labtests NZ	30	29	17	58.6
MedLab Central	5	5	2	40.0
Middlemore Hospital	4	4	4	100.0
SCL Kew	3	3	2	66.7
SCL Dunedin	4	4	4	100.0
PathLab Bay of Plenty	3	2	1	50.0
Waikato Hospital	3	3	3	100.0
PathLab Waikato	2	2	2	100.0
SCL Hastings	1	1	1	100.0
Whangarei Hospital	1	1	1	100.0
LabPlus	1	1	0	0.0
Total	**57**	**55**	**37**	**67.3**

[1] Due to insufficient sample submitted, not all samples received could be tested

In addition, negative samples were submitted by Middlemore, Hutt and Wellington Hospital laboratories to ESR. Three samples that were submitted as rotavirus negative were positive when tested by RT-qPCR and were also genotyped. G and P genotyping of the 40 samples that tested positive at ESR identified G12P[8] as the predominant (19/40, 47.5%) rotavirus genotype (Table 10).

Table 10. Genotype distribution of samples that tested positive at ESR, non-sentinel surveillance, December 2014–December 2015

Genotype	Number	Percent
G3P[8]	2	5.0
G3P[9]	1	2.5
G4P[8]	2	5.0
G6P[14]	1	2.5
G8P[8]	3	7.5
G9P[8]	9	22.5
G10P[8]	1	2.5
G12P[8]	19	47.5
G1P[nt] vaccine-like	1	2.5
GntP[8] vaccine-like	1	2.5
Total	**40**	**100.0**

COMBINED GENOTYPING FROM SENTINEL AND NON SENTINEL SITES

Combining the non-sentinel and sentinel laboratory data, G12P[8] remained the predominant (28/59, 47.5%) rotavirus genotype. Three rotaviruses, G1P[nt], G1P[8] and GntP[8] were identified as vaccine-like (Table 11). The majority (53/59, 89.8%) of the genotyped samples were from cases aged under 5 years.

Table 11. Genotype distribution, combined sentinel and non-sentinel sites, December 2014–December 2015

Genotype[1]	Number	Percent
G1P[8]	4	6.8
G3P[8]	2	3.4
G3P[9]	1	1.7
G4P[8]	2	3.4
G6P[14]	1	1.7
G8P[8]	3	5.1
G9P[8]	13	22.0
G10P[8]	1	1.7
G12P[8]	28	47.5
GntP[8]	1	1.7
G1P[8] vaccine-like	1	1.7
G1P[nt] vaccine-like	1	1.7
GntP[8] vaccine-like	1	1.7
Total	**59**	**100.0**

[1] Includes three samples that were submitted as rotavirus negative

Table 12 shows the genotype distribution by vaccination status. Ten (16.9%) genotyped samples were from fully immunised children, however none of these were vaccine-like types.

Table 12. Genotype distribution by vaccination status, combined sentinel and non-sentinel laboratory sites, December 2014–December 2015

Genotype	Fully immunised[1]		Partially immunised		Not immunised	
	Number	Percent[2]	Number	Percent[2]	Number	Percent[2]
G1P[8]	1	10.0	0	0.0	3	6.7
G3P[8]	0	0.0	0	0.0	2	4.4
G3P[9]	0	0.0	0	0.0	1	2.2
G4P[8]	1	8.3	0	0.0	1	2.2
G6P[14]	0	0.0	0	0.0	1	2.2
G8P[8]	0	0.0	0	0.0	3	6.7
G9P[8]	3	30.0	0	0.0	10	22.2
G10P[8]	0	0.0	0	0.0	1	2.2
G12P[8]	5	50.0	1	25.0	22	48.9
GntP[8]	0	0.0	0	0.0	1	2.2
G1P[8] vaccine-like	0	0.0	1	25.0	0	0.0
G1P[nt] vaccine-like	0	0.0	1	25.0	0	0.0
GntP[8] vaccine-like	0	0.0	1	25.0	0	0.0
Total	**10**	**100.0**	**4**	**100.0**	**45**	**100.0**

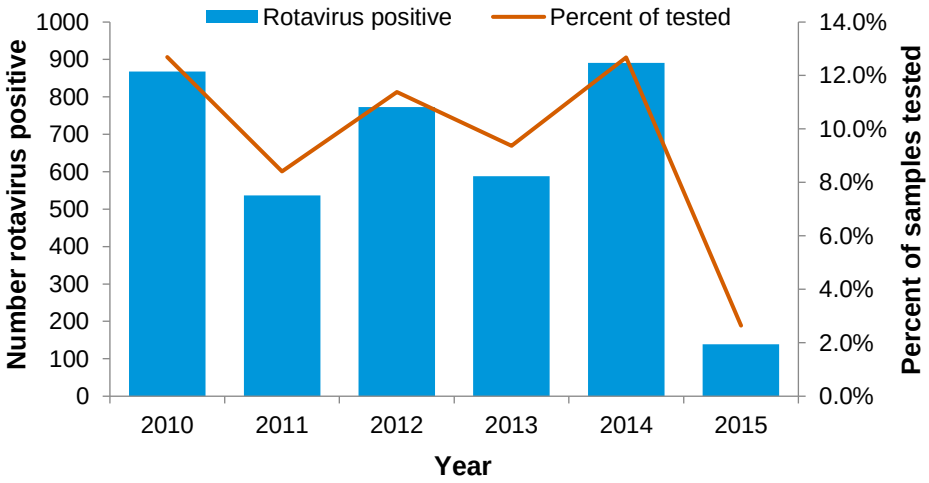
[1] Fully immunised = three doses (regardless of age)
[2] Percent of column total

COMMUNITY AND HOSPITAL LABORATORY TESTING

The following figures show the number of faecal samples tested and the proportion that were positive for rotavirus at Labtests NZ (covering the Auckland and Northland regions) and SCL (covering Southern, South Canterbury, Canterbury and Nelson-Marlborough DHBs, and Hawke's Bay and Taupo regions).

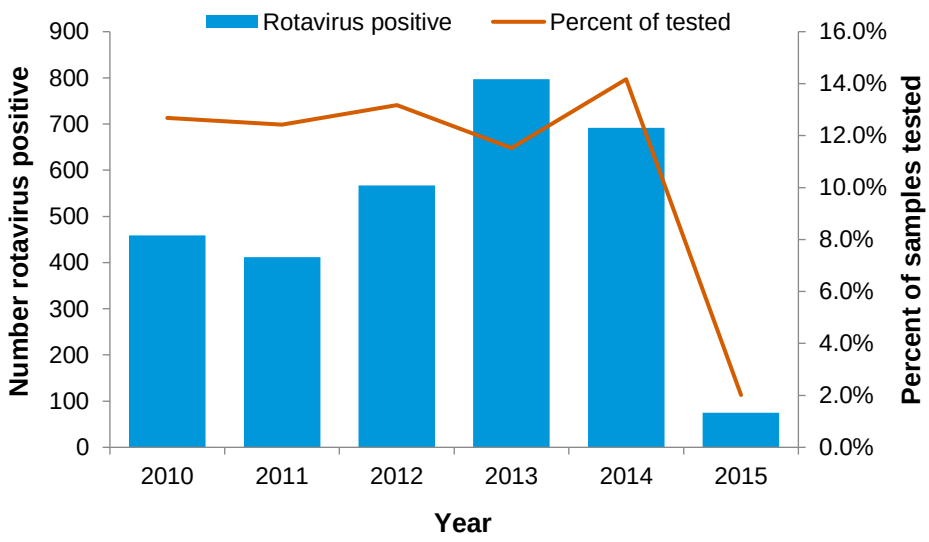
Figure 13 shows data from Labtests NZ from 2010 to 2015. There was a dramatic reduction in the number of rotavirus-positive samples in 2015 when 139 samples tested were positive for rotavirus compared with an annual average of 731 in the preceding five years. The proportion of gastroenteritis samples that were rotavirus positive declined from an average of 10.9% in 2010–2014 to 2.6% in 2015. Prior to 2 November 2015 faecal samples submitted to Labtests NZ for children aged 3 years and under were routinely tested for rotavirus, however from November 2015 samples were only tested for rotavirus on request. There was a decline in the overall number of samples submitted for testing in 2015 (Figure 17 in the appendix).

Figure 13. Number of rotavirus-positive samples and as a proportion of faecal samples tested for children aged under 5 years, Labtests NZ, 2010–2015



A similar pattern was seen for SCL, with 75 rotavirus-positive samples for 2015 compared with an annual average of 585 for 2010–2014. The proportion of faecal samples that were positive for rotavirus in 2015 was 2.0% compared with an average of 12.8% for 2010–2014 (Figure 14). Faecal samples submitted to SCL for children aged 3–5 years or younger (varying by laboratory) were routinely tested for rotavirus with other ages only tested on request. There was a decline in the overall number of samples submitted for testing in 2015 (Figure 18 in the appendix).

Figure 14. Number of rotavirus-positive samples and as a proportion of faecal samples tested for children aged under 5 years, SCL, 2010–2015



The monthly distribution of rotavirus-positive samples for both Labtests NZ (Figure 15) and SCL (Figure 16) shows a marked increase in the winter and spring in 2013 and 2014, however this increase was not apparent in 2015.

Figure 15. Number of rotavirus-positive samples for children aged under 5 years by month, Labtests NZ, 2013–2015

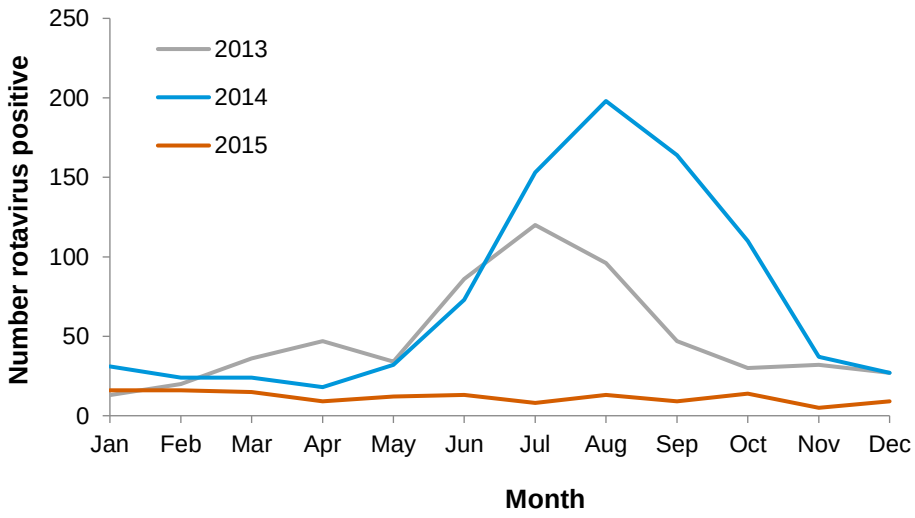
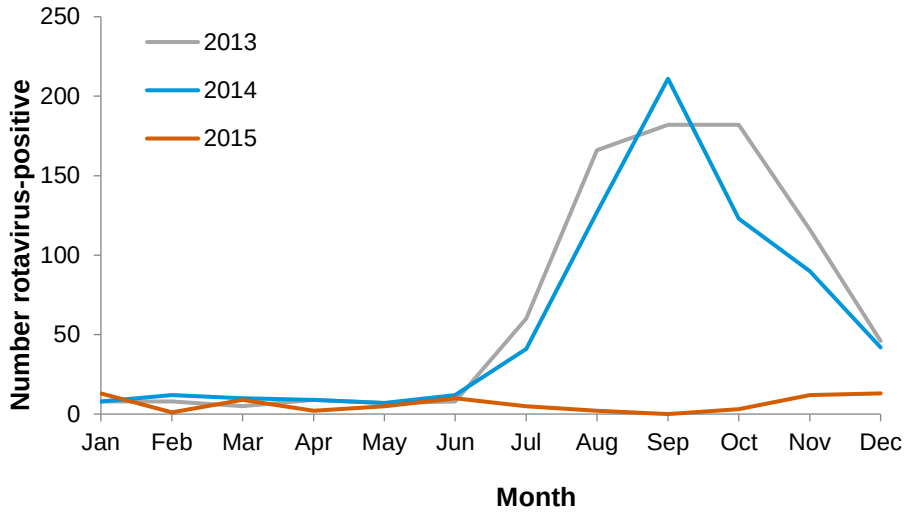


Figure 16. Number of rotavirus-positive samples for children aged under 5 years by month, SCL, 2013–2015



DISCUSSION

Vaccine coverage and choice

Fully funded rotavirus vaccination was introduced on 1 July 2014 using the RotaTeq® vaccine. Eighteen months after vaccine introduction, vaccine coverage for children aged 8 months was reported as 87.2% for the last quarter (October-December) in 2015. Rotavirus vaccine coverage was similar for all ethnicities and for the most deprived quintile. The Better Public Services vaccine coverage target for all age-appropriate vaccinations by 8 months of age is 95%. However, due to its recent introduction, rotavirus vaccine coverage is not yet included in milestone age coverage target reports.

Natural rotavirus infection in young children does not provide full immunity against reinfection but does protect against severe disease from reinfection. Initial infections give a serotype-specific response and subsequent infections give a broader serotype cross-reactive response [14, 15]. It was on this basis that rotavirus vaccines were introduced. RotaTeq® is a pentavalent vaccine consisting of five reassortant rotaviruses that does not replicate well in humans but relies on neutralising antibodies being raised against the specific rotavirus types in the vaccine. This means that if the most common disease-causing types are not in the vaccine the vaccine may not be protective and a change in type composition may be required. By contrast, Rotarix® is a monovalent vaccine that does replicate well in humans and provides protection similar to natural infection, with repeated infections giving cross-protection against most other serotypes [14]. Both rotavirus vaccines, RotaTeq® and Rotarix®, have demonstrated excellent protection against severe rotavirus gastroenteritis caused by common genotypes in efficacy trials and in post-introduction surveillance [14, 16-19]. However, vaccine protection against newly emerging genotypes is not well known and national surveillance of circulating rotavirus types following vaccination is necessary [14].

PHARMAC has announced that from 1 July 2017, New Zealand will change the funded rotavirus vaccine from the pentavalent vaccine RotaTeq® with its three dose schedule, to the monovalent vaccine Rotarix® with a two-dose schedule. Vaccine effectiveness should persist, but ongoing laboratory surveillance will be important to ensure adequate protection through the chosen vaccine.

Epidemiology

Prior to the addition of RotaTeq® vaccine into the standard vaccination schedule for New Zealand infants, published annual rates of rotavirus hospitalisations varied from about 150 to over 650 per 100,000 (Table 2). Our analysis of hospitalisations support these rates with an average annual rate of 215 per 100,000 for 2010–2014 nationally, varying by DHB from 57 to 427 per 100,000 (Table 17). It should be noted that there are variable rotavirus testing practices across the country with some centres not routinely testing for rotavirus. Therefore,

rates of rotavirus using hospital coding data that may be informed by varying laboratory testing practices are likely to underestimate the true rate. Following vaccine introduction, the annual rate for rotavirus hospitalisation decreased to 32 per 100,000, again varying by DHB from 0 to 63 per 100,000. As expected, coding practices notwithstanding, it appears that the vaccine has been effective in decreasing the most severe rotavirus disease that results in hospitalisation. Disparities by socioeconomic deprivation remain with most hospitalised cases from quintiles 4 and 5 (Figure 7, Table 16).

In addition, the community laboratory data support the large decrease in rotavirus infections in the community, with the number of rotavirus-positive samples decreasing following the introduction of the vaccine. The proportion of faecal samples that were positive for rotavirus decreased from a peak of 12–14% pre-vaccine introduction to less than 3% in 2015 post-vaccine introduction (Figure 13 and Figure 14).

The pattern of rotavirus infection is cyclical with variation in rotavirus infections by year pre-vaccine introduction. The rotavirus vaccine was introduced in New Zealand mid-way through a high incidence year, therefore we expected a lower number of rotavirus infections in 2015 regardless of the vaccine. However, the decline post-vaccine introduction is marked. In addition to a vaccine impact, there may have been some herd effect and/or high levels of immunity in the non-eligible children from past infection that contributed to the large decline. As the vaccine was introduced without a catch-up campaign, not all infants and young children were eligible for vaccination by the start of 2015. Another year of data will demonstrate the impact from rotavirus vaccination as the cohort of children eligible and fully vaccinated increases.

Sentinel surveillance

Following rotavirus vaccine introduction, national and sentinel surveillance is necessary to monitor trends of severe rotavirus infection i.e. hospitalisations with rotavirus infection. A single sentinel surveillance site (Kidz First Children's Hospital) collected data on all gastroenteritis hospitalised cases and compared severity of illness for rotavirus-positive and rotavirus-negative gastroenteritis (Table 21). Consistent with other studies, the children hospitalised with rotavirus gastroenteritis had a longer duration of stay; more severe symptoms including moderate dehydration; nasogastric intubation; and intravenous fluid replacement compared to children hospitalised with non-rotavirus gastroenteritis. However, due to the small number of confirmed rotavirus cases, only moderate dehydration was statistically significant.

Genotyping

Rotavirus surveillance is also important to determine if variability in genotypes is due to secular trends or whether vaccine pressure results in selection of certain genotypes.

Genotype G12P[8] was the predominant type identified, accounting for 47.5% of samples that were genotyped (Table 11). This compares to a previous New Zealand study conducted

over the period June 2005–May 2006 where no G12 types were identified [13]. In that study, the most common type identified was G1 (55.8% samples) followed by G4 (21.4% samples). The P type was only identified in 10% samples.

Rotavirus vaccinations were publicly funded for infants in all states and territories in Australia from 1 July 2007. Both RotaTeq® and Rotarix® vaccines were introduced simultaneously with RotaTeq® used in Victoria, South Australia, Queensland and Western Australia, and Rotarix® used in Northern Territory, New South Wales, Tasmania and the Australian Capital Territory. The G12P[8] genotype emerged in Australia in 2012 and became the predominant genotype identified in 2013 [21]. By 2014, G12P[8] was also the most common genotype identified both in children aged under 5 years (26%, 125/480) and across all ages (29.6%, 217/733). G12P[8] was most common in locations where the RotaTeq® vaccine was used but was not identified from regions where Rotarix® was used.

G12P[8] has also been detected in Asia, Africa, the US and Europe. The European Rotavirus Network, EuroRotaNet, reported an overall increase in the identification of G12P[8] in European countries in 2014/15 when G12P[8] accounted for 10% (604/5849) of genotypes identified compared with 3% in the previous two seasons [22]. Prior to the 2009/10 season, G12P[8] accounted for less than 1% in these European countries. G12P[8] has also been associated with large localised outbreaks, including in Italy and the US [23, 24]. The New Vaccine Surveillance Network in the US [25] conducts active surveillance of acute gastroenteritis in children at seven sentinel sites and identified a large increase in the proportion of rotavirus-positive samples that were G12 types from prior to 2010 to 2013. Prior to 2010, less than 10% of identified rotavirus types were G12 compared to 68% in 2013 [26].

G9P[8] was the second most common genotype identified in our surveillance, accounting for 22% of samples that were genotyped. This proportion is similar to the overall proportion of 20% in Europe in 2014/15 [22]. In Australia G9P[8] accounted for a small proportion (<3%) of identified genotypes prior to 2014 but in 2014 was identified in 7.5% of rotaviruses, being more common in regions using Rotarix® [21].

The identification of G6P[14], albeit in one sample, is of interest as this is seldom reported in the published literature, although another P[14] virus (G8P[14]), was identified in the 2005/06 New Zealand study [13]. The G10 type has not been previously reported in New Zealand.

Recent systematic reviews and meta-analyses report that post-vaccine introduction has not resulted in any consistent selective pressure of circulating rotavirus types resulting from vaccine use [27, 28]. Both the RotaTeq® and Rotarix® vaccines are effective against diverse rotavirus types and are highly effective against severe rotavirus disease [29, 30]. Even though there may be a relative increase of some specific genotypes, there has been no absolute increase in the incidence of rotavirus infection from those specific genotypes [28, 31].

Screening tests

Although no formal evaluation of the rotavirus screening tests used in New Zealand was done, the diagnostic procedures used by New Zealand laboratories do vary. At least three different assays were used by laboratories participating in the non-sentinel surveillance component of the study. A comparison by Middlemore Hospital Laboratory of two commercial assays identified discordant results, with preliminary results showing that one assay may have suboptimal test specificity. Further evaluation of the effect of lower specificity on rotavirus diagnostics may be warranted given the low prevalence of rotaviruses since the introduction of the vaccine in 2014. New Zealand laboratories will need to review and change as necessary their assays, moving towards highly specific antigen detection tests, to ensure optimal test sensitivity and specificity and an acceptable positive predictive value.

Limitations

Active surveillance for rotavirus infections began only after the introduction of the rotavirus vaccine into the New Zealand childhood immunisation schedule. As such, we have relied on routinely collected hospitalisation data and passive surveillance from community laboratory data to demonstrate the impact of the vaccine on rotavirus cases and rates. Nevertheless, there is clear evidence of vaccine effectiveness.

Due to the small number of faecal samples tested, genotypes with a low prevalence may not be detected. EuroRotaNet reported the presence of over 50 different genotypes from over 57000 rotaviruses between 2006 and 2015 [22].

Conclusion

This report presents the change in rotavirus infections following vaccine introduction from hospital discharges, sentinel surveillance and laboratory findings. Despite limitations in the data, there has clearly been a significant decrease in the numbers and rates of rotavirus infections and the proportion of rotavirus of all gastroenteritis infections. PHARMAC has announced that from 1 July 2017, New Zealand will change rotavirus vaccine to the monovalent vaccine Rotarix® with a two-dose schedule. Surveillance of rotavirus hospitalisations through sentinel surveillance sites, review of national hospitalisation data, and laboratory genotyping will be continued to monitor trends of severe rotavirus infection and vaccine selection pressure on rotavirus genotypes, particularly with a change in vaccine.

APPENDIX

DATA TABLES

Table 13. Rotavirus vaccine coverage at age 8 months by quarter, September 2014–December 2015

Quarter ending	Total	Māori	Pacific	NZDep2013 9–10
December 2014[1]	41.1%	34.1%	35.6%	33.0%
March 2015	82.0%	79.1%	85.0%	79.2%
June 2015	85.6%	83.5%	88.5%	84.3%
September 2015	86.7%	84.9%	91.9%	86.0%
December 2015	87.2%	86.2%	90.7%	85.4%

[1] Rotavirus vaccination was introduced into the New Zealand schedule on 1 July 2014

Table 14. Number and rate of rotavirus hospital discharges for children aged under 5 years by age, 2010–2015

Age	2010		2011		2012		2013		2014		2015	
	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]
<1 year	292	452.5	246	391.7	202	330.1	146	242.3	227	385.5	30	50.8
1 year	319	498.8	228	353.4	255	406.8	209	340.6	313	516.5	34	57.2
2 years	150	232.9	96	150.4	109	169.7	93	148.7	146	236.3	20	32.7
3 years	45	72.4	43	66.9	36	56.6	38	59.1	61	96.9	10	16.0
4 years	16	27.0	11	17.7	21	32.8	24	37.8	23	35.6	5	7.9

[1] Rate per 100,000 population

Table 15. Number and rate of rotavirus hospital discharges for children aged under 5 years by ethnic group, 2010–2015

Ethnic group	2010		2011		2012		2013		2014		2015	
	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]
Māori	231	272.8	183	214.0	173	203.4	118	140.4	205	246.4	31	37.6
Pacific	85	274.5	95	303.8	68	218.6	67	218.0	81	266.2	10	33.2
Asian	72	192.0	44	116.2	66	175.2	68	182.7	88	238.9	20	54.8
MELAA[1]	15	333.7	14	308.4	16	354.4	11	246.6	15	339.7	2	-
European /other	417	266.1	288	182.0	300	190.6	244	158.2	380	246.9	36	23.6

[1] Rate per 100,000 population

Table 16. Number and rate of rotavirus hospital discharges for children aged under 5 years by socioeconomic deprivation, all New Zealand, 2010–2014 average compared with 2015

NZDep2013 quintile	2010–2014 average				2015			
	Number	Rate[1]	95% CI	P-value[2]	Number	Rate[1]	95% CI	P-value[2]
1	83	151.6	118.9–184.2	-	17	31.8	16.7–47.0	-
2	78	136.0	105.8–166.2	0.5	11	19.7	8.0–31.3	0.21
3	112	187.3	152.6–222.0	0.1	10	17.2	6.5–27.8	0.12
4	158	251.8	212.5–291.0	<0.01	22	36.0	20.9–51.0	0.71
5	238	301.3	263.0–339.6	<0.01	39	50.7	34.8–66.5	0.11

[1] Rate per 100,000 population

[2] Two-tailed test with quintile 1 as the reference value

Table 17. Number and rate of rotavirus hospital discharges for children aged under 5 years by DHB, 2010–2014 average compared with 2015

DHB	2010–2014 average		2015	
	Number	Rate[1]	Number	Rate[1]
Northland	30	260.9	0	0.0
Waitemata	87	222.2	16	40.3
Auckland	51	173.0	19	63.1
Counties Manukau	72	169.4	26	62.4
Waikato	75	268.5	3	-
Lakes	24	298.0	1	-
Bay of Plenty	63	427.0	7	47.5
Tairawhiti	15	381.3	1	-
Taranaki	16	200.3	4	-
Hawke's Bay	38	330.8	0	0.0
Whanganui	11	263.5	2	-
MidCentral	21	178.6	1	-
Hutt Valley	39	368.7	0	0.0
Capital & Coast	42	219.4	3	-
Wairarapa	10	352.4	0	0.0
Nelson Marlborough	12	136.4	0	0.0
West Coast	4	-	0	0.0
Canterbury	18	56.8	10	31.5
South Canterbury	4	-	2	-
Southern	38	199.9	4	-
Total	**670**	**215.4**	**99**	**32.4**

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

NOTE there are different testing practices among DHBs with some routinely testing young children and some only testing on request.

Table 18. Number of confirmed rotavirus cases for children aged under 5 years by age, Kidz First Children's Hospital, 12 December 2014–31 December 2015

Age	Number
<1 year	4
1 year	6
2 years	6
3 years	2
4 years	1

Table 19. Number of confirmed rotavirus cases for children aged under 5 years by ethnicity, Kidz First Children's Hospital, 12 December 2014–31 December 2015

Ethnic group	Number
Māori	3
Pacific	4
Asian	7
MELAA[1]	0
European / other	5

[1] Middle Eastern, Latin American, African

Table 20. Number of confirmed rotavirus cases for children aged under 5 years by socioeconomic deprivation, Kidz First Children's Hospital, 12 December 2014–31 December 2015

NZDep2013 quintile	Number
1	1
2	0
3	0
4	2
5	16

Table 21. Severity of rotavirus and rotavirus-negative hospitalisations for children aged under 5 years, Kidz First Children's Hospital, 12 December 2014–31 December 2015

Severity measure	Rotavirus positive (N=19)		Rotavirus negative (N=133)		P-value
	Number	Percent	Number	Percent	
Patient type					
inpatient	10	52.6	55	41.4	0.18
outpatient	9	47.4	78	58.7	0.82
Dehydrated					
mild	11	57.9	104	78.2	0.97
moderate	8	42.1	29	21.8	0.03*
Bloods collected					
no	10	52.6	85	63.9	0.83
yes	9	47.4	48	36.1	0.17
Nasogastric intubation					
no	12	63.2	97	73.5	0.83
yes	7	36.8	35	26.5	0.17
IV fluid replacement					
no	14	73.7	111	83.5	0.85
yes	5	26.3	22	16.5	0.15
Admitted to ICU					
no	19	100.0	131	99.2	0.35
yes	0	0.0	1	0.8	0.65
Died					
no	19	100.0	132	100.0	-
yes	0	0.0	0	0.0	-
Transferred to another hospital					
no	19	100.0	131	98.5	0.3
yes	0	0.0	2	1.5	0.7
Neurological impairment					
no	19	100.0	133	100.0	-
yes	0	0.0	0	0.0	-
Associated febrile seizures					
no	18	94.7	131	99.2	0.95
yes	1	5.3	1	0.8	0.05
Sodium concentration (mmol/L)					
<135	5	55.6	10	20.8	0.02*
135–145	4	44.4	38	79.2	0.99
>145	0	0.0	0	0.0	-

[1] One tailed p-value comparing rotavirus-positive with rotavirus-negative cases; * significant at 0.05

Figure 17. Number of faecal samples tested and rotavirus positive for children aged under 5 years, Labtests NZ, 2010–2015

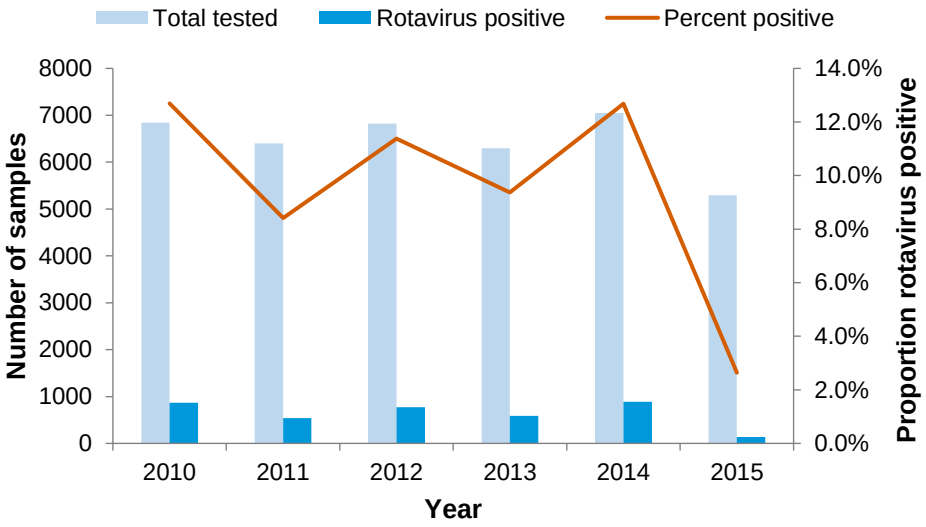
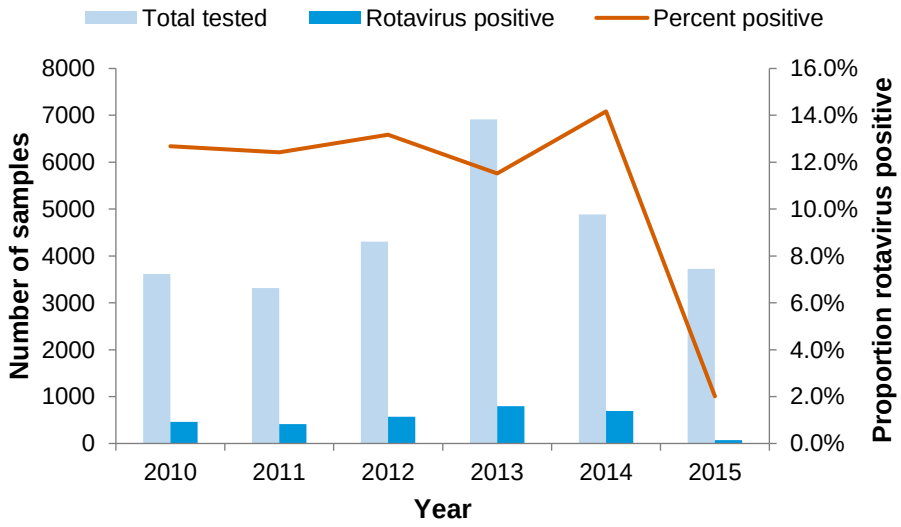


Figure 18 . Number of faecal samples tested and rotavirus positive for children aged under 5 years, SCL, 2010–2015



LABORATORY METHODS

Sample preparation and rotavirus confirmation assay

Approximately 0.2 g of faeces was added to 2 ml virus transport medium and 200 µl chloroform and vortexed to make a suspension. The mixture was then clarified by centrifugation at 12,000 g for 10 min at 4ºC. Viral nucleic acids were extracted from 200 µl of the supernatant using the Roche High Pure® Viral Nucleic Acid Extraction Kit (Roche Molecular Biochemicals Ltd., Mannheim, Germany). Viral RNA stored at -80 °C until RT-qPCR analysis.

A one-step real-time RT-qPCR method, using the primers and probe and following the PCR parameters described by Pang, Lee, Boroumand *et al.* [32], was performed using the Invitrogen Superscript III One-Step System (Invitrogen, Carlsbad, CA). Real-time RT-qPCR assays were carried out in a Rotor-Gene 3000 rotary analyser (Corbett Life Science, Sydney, Australia). Raw data were analysed using the Rotor-Gene™ software.

Genotyping

Samples that were positive for rotavirus by RT-qPCR were genotyped.

Genotyping protocols were based on those recommended by Dr Carl Kirkwood and used for the Australian Rotavirus Surveillance Programme [21]. The G and P genotype of each RT-qPCR confirmed rotavirus-positive sample was determined by analysis of VP7 and VP4. This was done using the Invitrogen SuperScript™ III One-Step RT-PCR System with Platinum® *Taq* DNA Polymerase, and using VP7- or VP4-specific primers (VP7F, VP7R, VP4F and VP4R). This was followed by hemi-nested multiplex PCR assays using Qiagen PCR mastermix and specific primers for either G and P types (with agarose gel analysis for visualisation of the specific band size), and/or using sequence analysis of PCR products generated by the initial VP7 or VP4 specific RT-PCR assay.

In accordance with the recommendations of the Rotavirus Classification Working Group, the online RotaC v2.0 rotavirus genotyping tool (http://rotac.regatools.be) and BLAST were used to enable typing following sequence analysis.

Following VP4 and VP7 typing, samples that potentially contained rotavirus vaccine/ vaccine-like viruses were subjected to VP6 typing which is used to distinguish between wild type and vaccine-like rotaviruses. These included samples genotyped as GI, G2, G3 and G4.

CASE REPORT FORM FOR SENTINEL HOSPITAL-BASED ROTAVIRUS SURVEILLANCE

Confidential

Case Report Form

Record ID _____

Admin details

Hospital site
- ◯ KidzFirst
- ◯ Wellington
- ◯ Christchurch

Encounter number (main) _____

Encounter number (additional) _____

Nurse
- ◯ Shirley (CMDHB)
- ◯ Kirstin (CMDHB)
- ◯ C
- ◯ D

Patient details

Last name _____

First name _____

NHI number _____

Date of birth _____

Sex
- ◯ Female
- ◯ Male
- ◯ Indeterminate
- ◯ Unknown

Ethnicity
- ☐ NZ European
- ☐ Maori
- ☐ Samoan
- ☐ Cook Island
- ☐ Tongan
- ☐ Niuean
- ☐ Other Pacific (e.g. Fijian, Tokelauan)
- ☐ Chinese
- ☐ Indian
- ☐ Other (e.g. Dutch, Japanese)

If Other Pacific, specify _____

If Other, specify _____

Street address _____

Suburb _____

City _____

Datetime of admission or seen in ED _____

Datetime of discharge _____

Eligible
- ◯ Yes
- ◯ No

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Verbal Consent
- ◯ Yes
- ◯ No

Sample details

Stool sample collected
- ◯ Yes
- ◯ No

Reason stool sample not collected _____

Date stool sample collected _____

Screening test result
- ◯ Positive
- ◯ Negative
- ◯ Not Done

Reason for not doing test _____

Gastrointestinal symptoms

Temperature (Co) _____
(1 decimal place)

Vomiting
- ◯ Yes
- ◯ No

Diarrhoea
- ◯ Yes
- ◯ No

Number of liquid stools in the 24 hours prior to admission _____

Severity and complications

Patient type
- ◯ Inpatient
- ◯ Outpatient

Dehydrated
- ◯ Mild
- ◯ Moderate

Bloods collected
- ◯ Yes
- ◯ No

Nasogastric intubation
- ◯ Yes
- ◯ No

Intravenous fluid replacement
- ◯ Yes
- ◯ No

Admitted to ICU
- ◯ Yes
- ◯ No

Died
- ◯ Yes
- ◯ No

Date of death _____

Transferred to another hospital
- ◯ Yes
- ◯ No

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Transferred to _____

Complications

Neurological impairment
- ◯ Yes
- ◯ No

Associated febrile seizures
- ◯ Yes
- ◯ No

Sodium tested
- ◯ Yes
- ◯ No

First sodium reading _____

Immunisation details

Immunised with RotaTeq?
- ◯ Yes
- ◯ No
- ◯ Unknown

No of doses of RotaTeq _____

Immunisation date 1 _____

Immunisation date 2 _____

Immunisation date 3 _____

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