Science for Communities

ROTAVIRUS IN NEW ZEALAND, 2016

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DISCLAIMER

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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 Dataset (hospital discharges)
NZDep	New Zealand index of deprivation
PCR	Polymerase chain reaction
REDCap	Research Electronic Data Capture
RT-qPCR	Real-time quantitative reverse transcription PCR
SCL	Southern Community Laboratories

SUMMARY

Rotavirus infections are a leading cause of severe gastroenteritis in young children worldwide [1]. Prior to the introduction of a rotavirus vaccine in New Zealand, it was estimated that 1 in 52 children were hospitalised with rotavirus gastroenteritis by 3 years of age [2]. The oral rotavirus vaccine RotaTeq® was added to the national immunisation schedule on 1 July 2014, and a marked decrease in rotavirus hospitalisations and community infections occurred in children under 5 years in 2015 [3].

This report presents information on rotavirus infections in 2016 from a variety of sources, including national hospital discharges, sentinel hospital-based surveillance and genotyping of rotavirus-positive samples from community and hospital laboratories.

In the two years following the introduction of rotavirus vaccine, there was an 88.7% decrease in the rate of rotavirus hospitalisations for children aged under 5 years compared with the previous five-year average (2010–2014). Socioeconomic disparities remain, with statistically significant higher rotavirus hospitalisation rates in children aged under 5 years in deprivation quintiles 4 and 5, compared with those in quintile 1.

Rotavirus surveillance is important to determine whether variability in genotypes is due to secular trends or whether vaccine pressure results in selection of certain genotypes. As in 2015, G12P[8] was the predominant rotavirus genotype detected in 2016, accounting for 55.4% of cases where a genotype was identified (47.5% in 2015). G2P[4] was the second most common genotype identified (19.1%), and had not been detected in 2015. Four samples were confirmed as containing a component of the RotaTeq® vaccine, including two from unvaccinated cases.

There has been a significant decrease in rotavirus hospitalisations and in rotavirus as a proportion of all gastroenteritis hospitalisations since the introduction of the vaccine in 2014. In July 2017, the rotavirus vaccine on the national immunisation schedule was changed to Rotarix®. Surveillance of rotavirus hospitalisations and laboratory genotyping will be important to monitor trends in severe rotavirus infection and vaccine selection pressure on rotavirus genotypes.

INTRODUCTION

Rotavirus infections are a leading cause of severe gastroenteritis in young children worldwide [1]. Compared with illness caused by other enteric pathogens, the diarrhoea due to rotavirus is particularly severe and often associated with vomiting and dehydration [4]. 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 [2]. Rotavirus infections typically peak in the second year of life and during winter and spring.

The rotavirus vaccine RotaTeq® was added to the national immunisation schedule on 1 July 2014, and is administered orally at 6 weeks, 3 months and 5 months of age. On 1 July 2017, the funded rotavirus vaccine was changed to the monovalent vaccine Rotarix® with a two-dose schedule.

Rotavirus is not a notifiable disease in New Zealand. Surveillance is based on national hospital discharges, sentinel hospital-based surveillance at four hospitals, and genotyping of rotavirus-positive samples from community and hospital laboratories. This report presents information on rotavirus infections in 2016 from each of these sources.

METHODS

SURVEILLANCE METHODS

The purpose of surveillance for rotavirus infections following the introduction of a rotavirus vaccine is outlined in the Centers for Disease Control and Prevention Manual for the Surveillance of Vaccine-Preventable Diseases [5].

“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.” [5]

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 2015 and 2016 were extracted for children aged 0–4 years. Records were extracted on 5 May 2017. New Zealand non-residents were excluded.

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, District Health Boards (DHBs) had differing admission practices resulting in differences in the data reported, therefore the data may not be comparable for the whole 2010–2016 period [6].

Sentinel hospital-based surveillance

Surveillance for rotavirus hospitalisation was implemented at Kidz First Children's Hospital in December 2014 and continued throughout 2016. Hospital-based surveillance was extended to Wellington, Hutt and Christchurch Hospitals where it operated between April and September 2016. However, Wellington hospital recorded some cases retrospectively, Christchurch Hospital recorded no cases after 11 August, and Hutt Hospital continued surveillance until the end of October. Therefore, the admission date ranges for the three additional sentinel surveillance hospitals were as follows:

- Wellington Hospital: 2 January to 14 September 2016;
- Christchurch Hospital: 2 April to 11 August 2016;
- Hutt Hospital: 29 April to 30 October 2016.

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 for laboratory screening for rotavirus. Any positive samples were then referred to the Institute of Environmental Science and Research (ESR) for typing.

Ethics approval

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

In order to establish surveillance at Christchurch Hospital, ethics approval was provided by the University of Otago Human Research Ethics Committee (reference H15/126).

Case definition

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 hospital admission) were excluded. Children who were readmitted, or seen in ED again, within 14 days with gastrointestinal illness were excluded for their second visit.

Case report form

A case report form (see appendix) covering demographic and clinical information was completed for each eligible child and entered into REDCap (Research Electronic Data Capture). REDCap is a free, secure, web-based application designed to support data capture for research studies.

Form 1 was used for all gastroenteritis cases at Kidz First Children's Hospital from December 2014 until April 2016. In April 2016, the form was revised and information on symptoms and severity was only recorded for rotavirus cases. This new form (form 2) was used by all four sentinel surveillance hospitals.

The data presented in this report is based on information recorded in REDCap as at 3 May 2017. Any changes made after this date are not reflected in this report. Laboratory results were matched with case data from the case report form.

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 dose 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 and 2016. The national coverage reports show the percentage of children who turned a milestone age during the quarter and have completed their age-appropriate immunisations.

LABORATORY METHODS

Rotavirus screening at sentinel sites

Faecal samples from the sentinel hospital-based surveillance sites were screened for rotavirus antigen using lateral flow immunoassays. Middlemore Hospital used both RIDA®QUICK Rotavirus/Adenovirus Combi (R-Biopharm, Germany) and Coris BioConcept GastroVir RIDA performed in parallel. If results were discrepant, the result was reported as indeterminate. Wellington and Hutt Hospitals used Coris BioConcept Rota-Strip and Christchurch Hospital used Coris BioConcept GastroVir.

Positive and indeterminate samples were sent to ESR.

Rotavirus screening at non-sentinel sites

All New Zealand community and hospital laboratories were asked to submit rotavirus-positive faecal samples from patients of any age to ESR for confirmation and genotyping. Tests used to detect rotavirus vary by laboratory.

Confirmation and genotyping

Confirmation for rotavirus was undertaken by ESR using real-time quantitative reverse transcription polymerase chain reaction (RT-qPCR). Samples confirmed as positive for rotavirus by RT-qPCR by ESR were genotyped according to the G and P typing system [7].

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

ANALYTICAL METHODS

Sentinel hospital-based surveillance

Data from both case report forms were combined using common fields. Any cases that were readmitted with gastroenteritis within 14 days were excluded for their second admission. Cases that tested positive for rotavirus were matched with ESR laboratory genotyping data by NHI number and date of sample collection.

Population rate calculations

The denominators used to calculate rates, except those used to determine disease rates for ethnic groups, were derived from the 2016 mid-year population estimates published by 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 [8].

Denominators used to determine disease rates for ethnic groups were 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 (2010–2016) population estimates from Statistics New Zealand.

New Zealand index of deprivation

Socio-economic deprivation was assigned using the 2013 New Zealand index of deprivation (NZDep2013). The NZDep2013 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 [9]. 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.

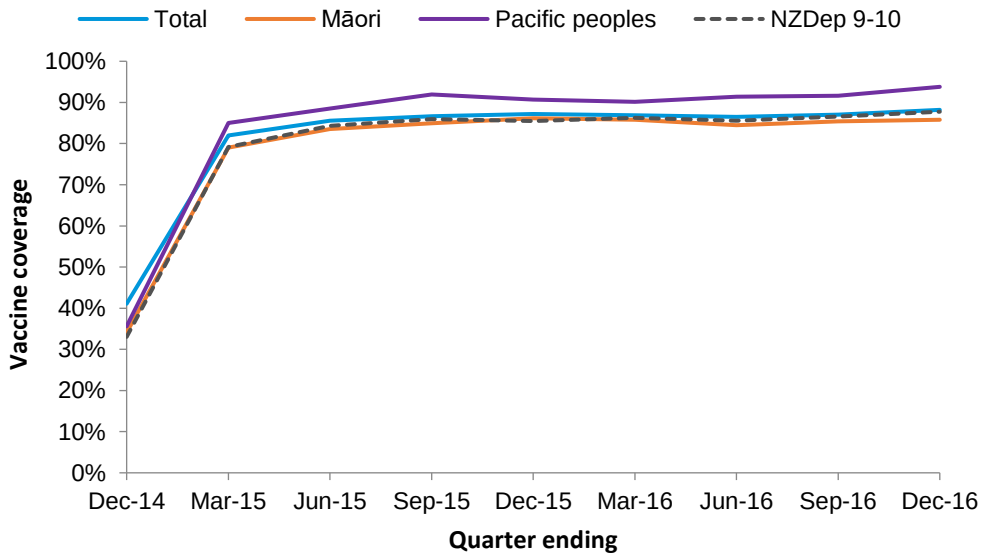
RESULTS

ROTAVIRUS VACCINE COVERAGE

As at December 2016, 88.2% of children aged 8 months were fully immunised against rotavirus (Figure 1, Table 8 in the appendix). For Māori the proportion was 85.8%, and for Pacific peoples this was 93.8%. For children living in NZDep2013 deciles 9 and 10 the proportion fully immunised was 87.7%.

At the beginning of 2016, children aged up to 19 months were eligible to fully immunised and by the end of 2016, children aged up to 31 months (2½ years) were eligible.

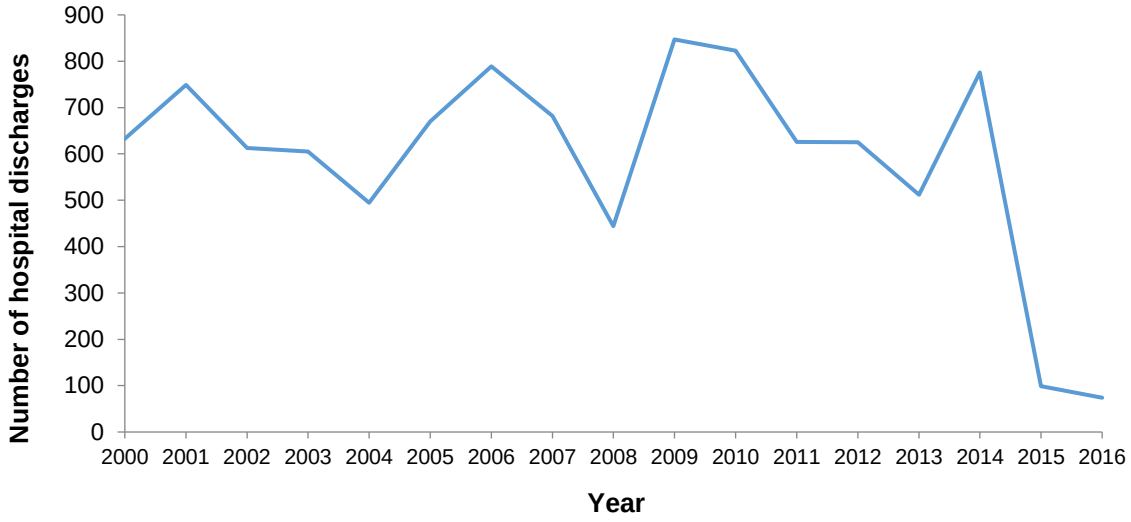
Figure 1. Rotavirus immunisation coverage at age 8 months by quarter, October 2014–December 2016



NATIONAL HOSPITAL DISCHARGES

There has been a marked decline in hospital discharges for rotavirus infection in children aged under 5 years since the vaccine was introduced. Between 2000 and 2014 the annual number of hospital discharges ranged from 444 to 847, decreasing to only 99 in 2015 and 74 in 2016 (Figure 2).

Figure 2. Rotavirus hospital discharges for children aged under 5 years, 2000–2016



Hospital discharges for rotavirus infection as a percentage of all gastroenteritis in children aged under 5 years also decreased from an average of 17.5% in 2010–2014 to 2.8% in 2016 (Table 1).

Table 1. Gastroenteritis and rotavirus hospital discharges for children aged under 5 years, 2010–2016

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	2334	763.3	99	32.4	4.2
2016	2657	872.5	74	24.3	2.8

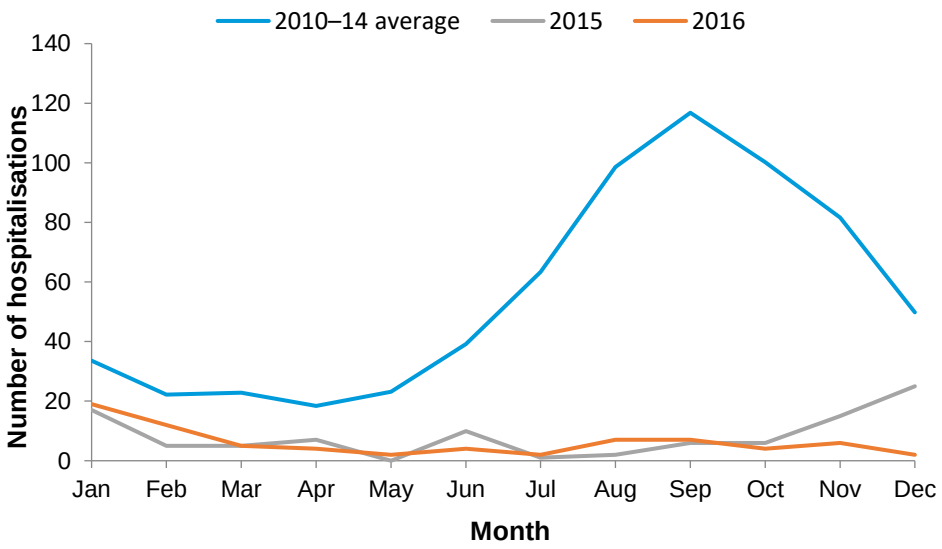
[1] Rate per 100,000 population

[2] Rotavirus as a percent of gastroenteritis hospital discharges

Monthly distribution

The usual seasonal peak for rotavirus hospitalisations for children aged under 5 years occurred around September in the years prior to vaccine introduction. However, in 2016, as in 2015, there was no distinct peak in hospitalisations and the highest monthly numbers were in December/January (Figure 3).

Figure 3. Rotavirus hospital discharges for children aged under 5 years by month, 2010–2014 average, 2015 and 2016



Age distribution

Of the 74 rotavirus hospitalisations for children aged under 5 years in 2016, 59.5% were male and 40.5% were female. The majority (81.1%) of cases were aged under 3 years (Table 2).

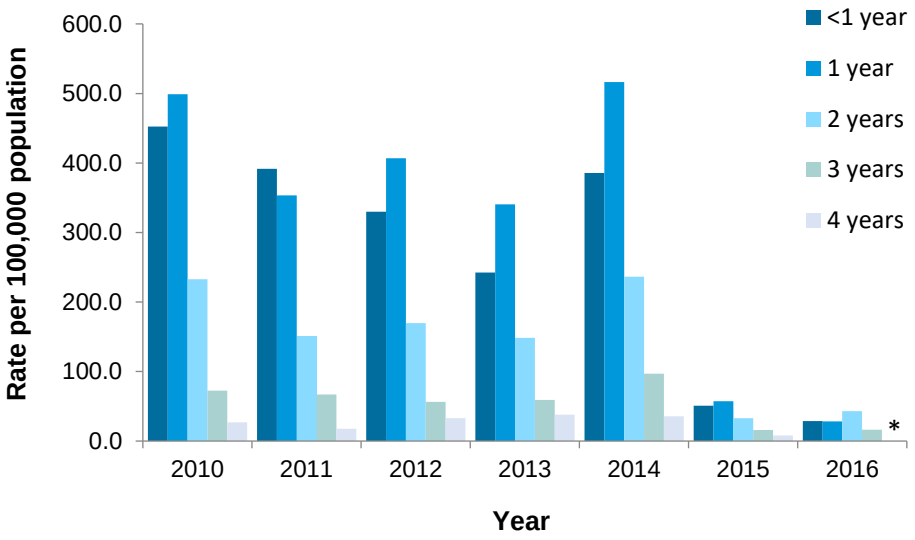
Table 2. Rotavirus hospital discharges for children aged under 5 years by age and sex, 2016

Age	Female	Male	Total	Percent[1]
<1year	8	9	17	23.0
1 year	4	13	17	23.0
2 years	8	18	26	35.1
3 years	8	2	10	13.5
4 years	2	2	4	5.4
Total	**30**	**43**	**74**	**100**

[1] Percent of the total number of rotavirus hospitalisations

Figure 4 (see also Table 9 in the appendix) shows rotavirus hospitalisation rates for children aged under 5 years by age and year for 2010–2016. For 2010–2015, the incidence was highest in the first two years of life and then rapidly decreased, however in 2016 the highest rate was seen in children aged 2 years.

Figure 4. Rotavirus hospital discharge rates for children aged under 5 years by age and year, 2010–2016

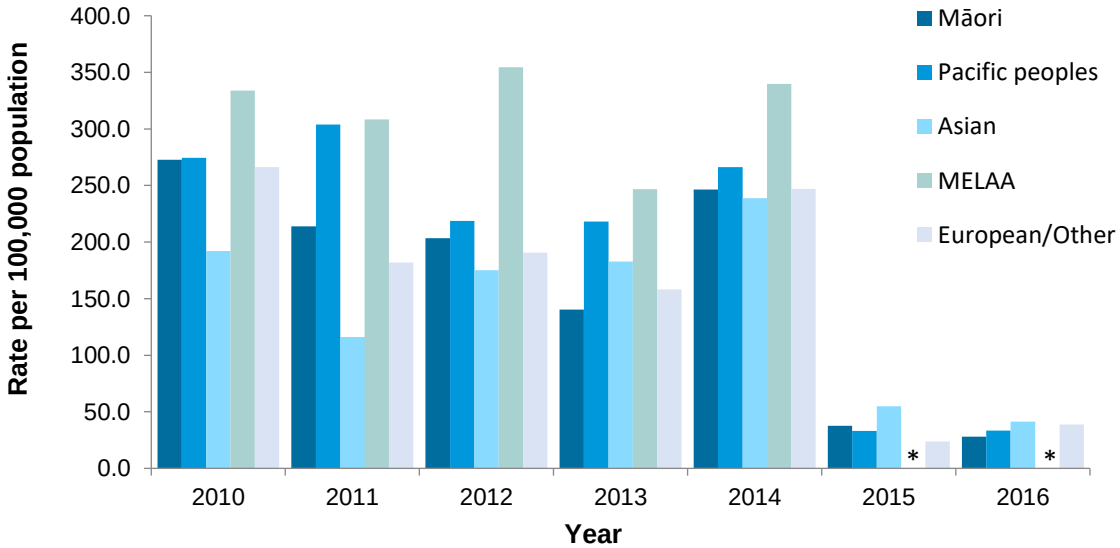


* Rate not calculated as less than five cases in this age group

Ethnic distribution

In 2015 and 2016, the highest rates were in Asian children (54.8 and 41.3 per 100,000 respectively. This is in contrast to 2010–2014 when the highest rates occurred in the MELAA ethnic group, followed by Pacific peoples and then Māori in most years, however the numbers for MELAA were much lower than for other ethnic groups (Figure 5 and Table 10 in the appendix).

Figure 5. Rotavirus hospital discharge rates for children aged under 5 years by ethnicity and year, 2010–2016



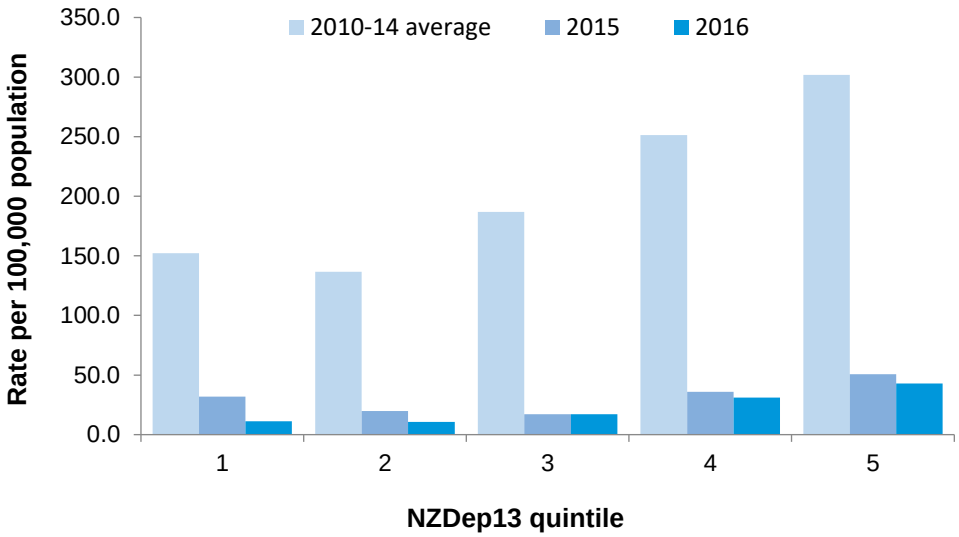
MELAA = Middle Eastern/Latin American/African

* Rate not calculated as less than five cases in this ethnic group

Socioeconomic distribution

The highest rates of rotavirus hospitalisation for children aged under 5 years were from the most socioeconomically deprived areas, NZDep2013 quintiles 4 and 5 (Figure 6). In 2016, as in 2010–2014, there was a statistically significant difference between quintile 1 and quintiles 4 and 5 ($P<0.05$) (Table 11 in the appendix).

Figure 6. Rotavirus hospital discharge rates for children aged under 5 years by socioeconomic deprivation, 2010–2014 average, 2015 and 2016

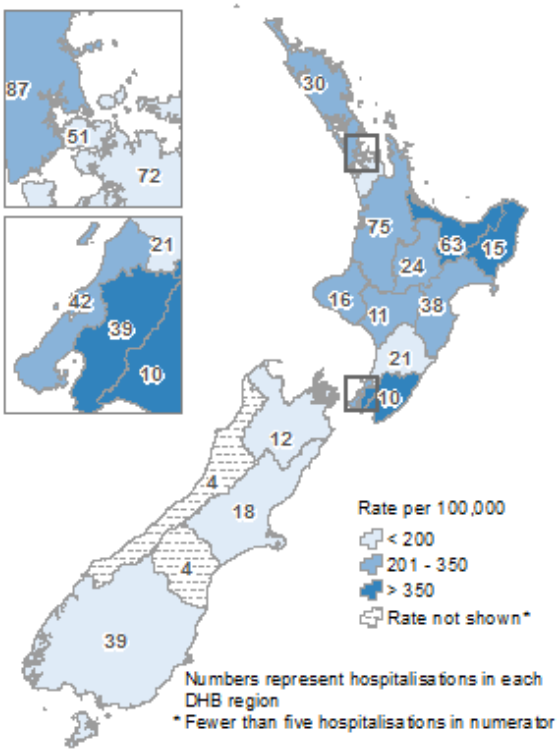


Geographic distribution

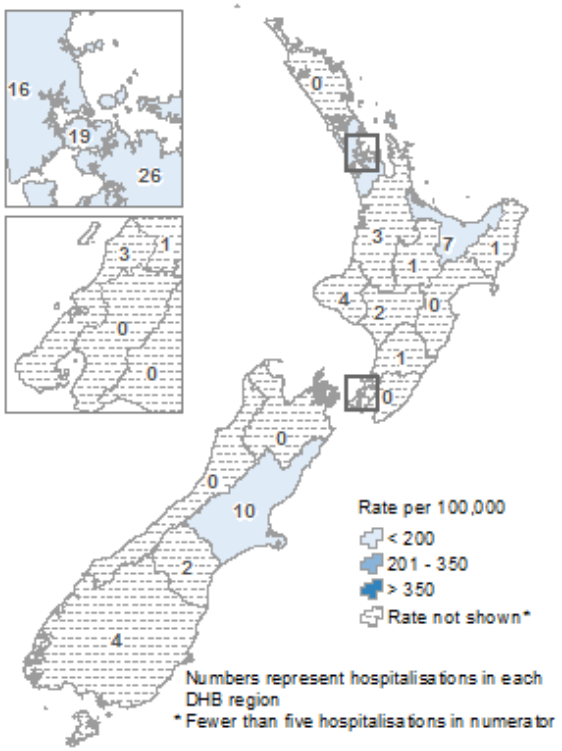
Figure 7 and Table 12 (in the appendix) show the number of rotavirus hospitalisation for children aged under 5 years by DHB for the 2010–2014 average, 2015 and 2016. For 2010–2014 the highest rates were from Bay of Plenty (427.0 per 100,000), Tairawhiti (381.3 per 100,000), Hutt Valley (368.7 per 100,000) and Wairarapa (352.4 per 100,000) DHBs, whereas in 2016 the highest rates were from Waikato (68.6 per 100,000 population), Counties Manukau (45.5 per 100,000), and Hawke's Bay (45.4 per 100,000) DHBs. Most DHBs had too few cases to calculate a rate.

Figure 7. Rotavirus hospital discharge rates for children aged under 5 years by DHB, 2010–2014 average, 2015 and 2016

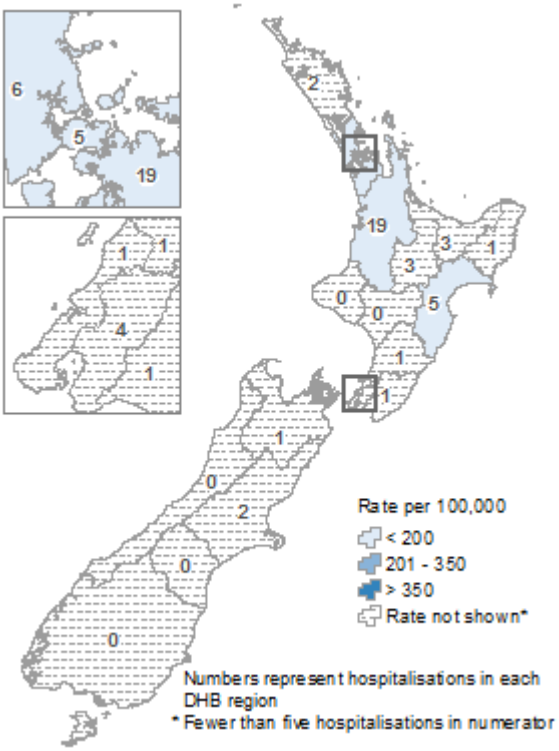
2010–2014 average



2015



2016



SENTINEL HOSPITAL-BASED SURVEILLANCE

During 2016, 722 cases of gastroenteritis in children aged under 5 years were detected through hospital-based surveillance at the four participating hospitals (Kidz First, Wellington, Hutt and Christchurch). Twenty-three cases were hospitalised for gastroenteritis more than once during the study period. One gastroenteritis case was readmitted within 14 days and the second admission was excluded from the analysis.

A specimen was taken from 205 (28.4%) of the 722 children with gastroenteritis. The main reason for being unable to obtain a sample was due to the child having no further diarrhoea while they were in hospital (80.3%). Other reasons were ward staff forgetting to collect a sample (10.7%) and being unable to get a sample (8.9%) e.g. due to watery diarrhoea.

Laboratory screening

Of the 205 gastroenteritis cases where a specimen was taken, 203 (99.0%) were screened for rotavirus and 18 (8.9%) of these tested positive for rotavirus antigen. An additional four samples were indeterminate and were referred to ESR along with the rotavirus-positive samples for confirmation and genotyping. One referred sample was not tested at ESR due to insufficient sample. Of the 21 tested, 17 (81.0%) were positive for rotavirus using RT-qPCR. The remaining four (19.0%) samples were negative using RT-qPCR.

The proportion of screened gastroenteritis specimens that were confirmed as rotavirus by RT-qPCR was 8.4% (17/203).

Figure 8 shows the total number of gastroenteritis cases that were detected, screened and confirmed positive by RT-qPCR from the sentinel hospital-based surveillance. Table 3 shows the number of gastroenteritis cases that were screened and confirmed positive by hospital site. The majority (19/22, 86.4%) of samples sent to ESR were from Kidz First hospital, while Christchurch hospital did not identify any positive samples through screening.

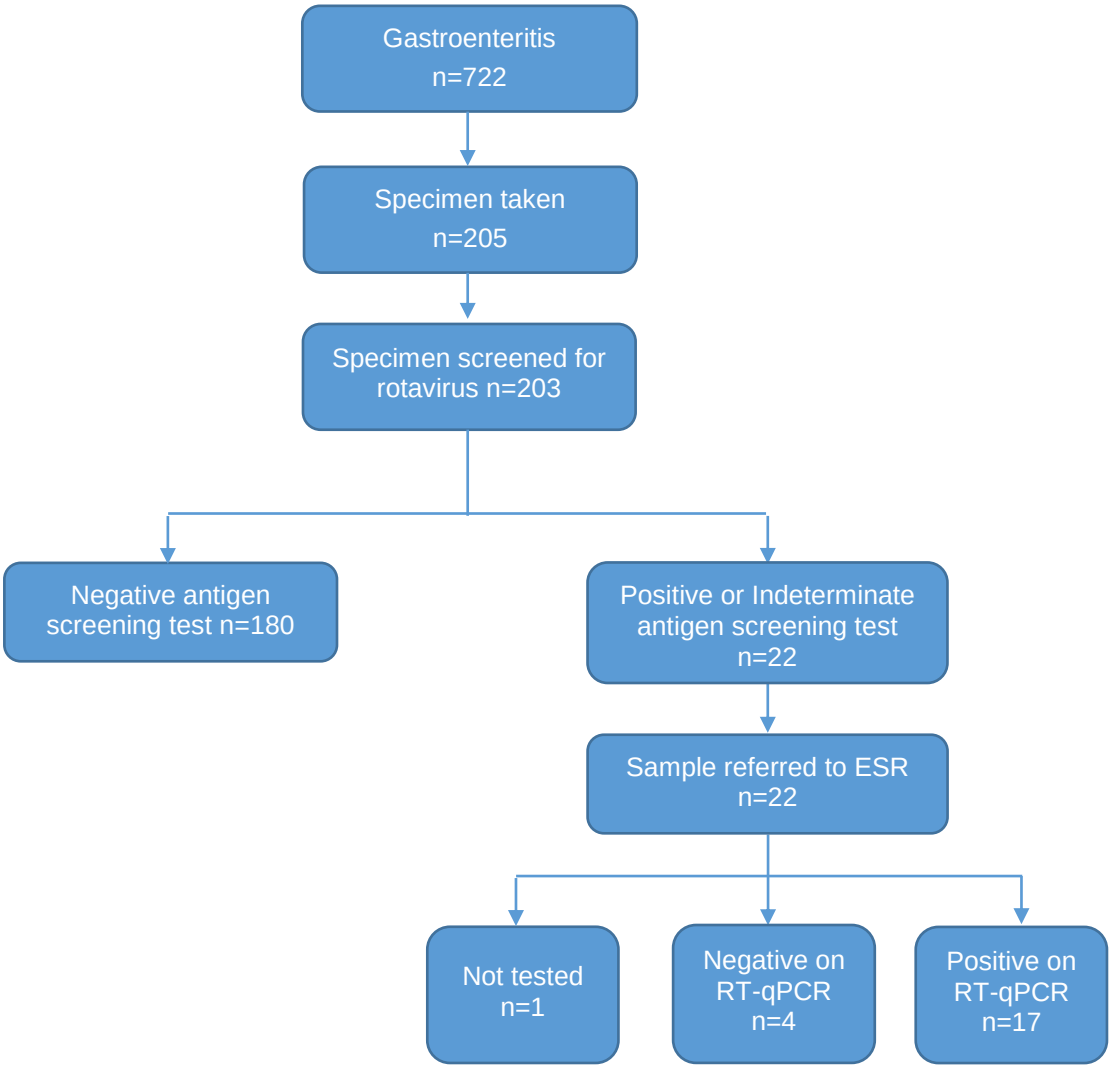
Table 3. Number of gastroenteritis cases in children aged under 5 years, sentinel surveillance hospitals, 2016

Hospital	Admission date range	Gastroenteritis cases	Specimen screened (%[1])	Rotavirus antigen positive or indeterminate (%[2])	RT-qPCR positive (%[2])
Kidz First	1 Jan–31 Dec	608	139 (22.9)	19 (13.7)	14 (10.1)
Wellington	2 Jan–14 Sep	46	38 (82.6)	1 (2.6)	1 (2.6)
Christchurch	2 Apr–11 Aug	53	13 (24.5)	0	0
Hutt	29 Apr–30 Oct	15	13 (86.7)	2 (15.4)	2 (15.4)
Total		**722**	**203 (28.1)**	**22 (10.8)**	**17 (8.4)**

[1] Percent of all gastroenteritis cases that were tested for rotavirus

[2] Percent of rotavirus tests that were antigen positive or RT-qPCR positive

Figure 8. Rotavirus case detection flow diagram for children aged under 5 years, sentinel surveillance hospitals, 2016



The rest of this section describes the 17 cases that were confirmed as rotavirus positive by RT-qPCR at ESR.

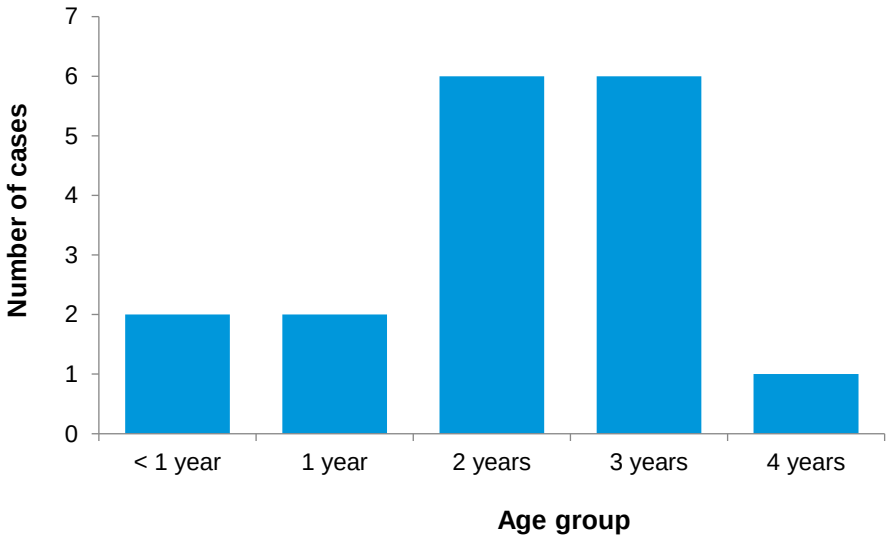
Incidence by month

The highest number of confirmed rotavirus cases occurred in January (4 cases), followed by November (3 cases) (Table 13 in the appendix). Most hospitals (Wellington, Christchurch and Hutt) did not conduct surveillance for the whole year (see Table 3) and so the number of cases by month for these sites are not directly comparable.

Incidence by age

Over two-thirds (12/17, 70.6%) of confirmed rotavirus cases occurred in children aged 2 and 3 years. Four cases (23.5%) were in children aged under 2 years (Figure 9, Table 14 in the appendix).

Figure 9. Number of confirmed rotavirus cases for children aged under 5 years by age, sentinel surveillance hospitals, 2016



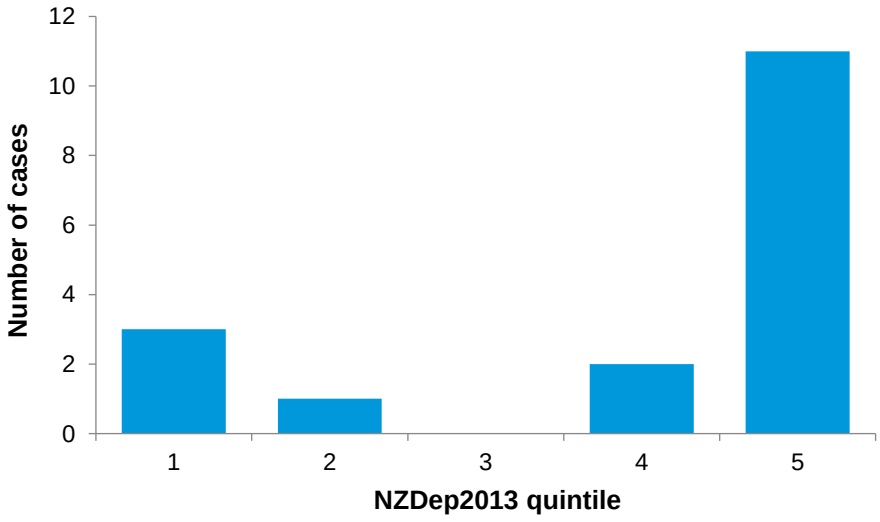
Incidence by ethnicity

Most of the confirmed rotavirus cases were of Asian ethnicity (6 cases: 4 Indian, 1 Chinese and 1 other Asian), followed by Māori and Pacific (4 cases each) (Table 15 in the appendix).

Incidence by deprivation

Over half (11/17, 64.7%) of the confirmed rotavirus cases were from the most socioeconomically deprived areas, NZDep2013 quintile 5 (Figure 10, Table 16 in the appendix).

Figure 10. Number of confirmed rotavirus cases for children aged under 5 years by ethnicity, sentinel surveillance hospitals, 2016



Disease presentation

Information on the severity of symptoms was provided for 16 confirmed rotavirus cases (Table 17 in the appendix). All 16 cases had both vomiting and diarrhoea. Three cases (3/16, 18.8%) had moderate or severe dehydration, and two of these had nasogastric intubation. There were no cases with neurological impairment or febrile seizures. No cases were admitted to an intensive care unit or died. The median length of hospital stay was 18.6 hours (range 2.1 hours to 4.2 days; 95% C.I. 5.9 hours to 3.1 days).

Immunisation status

The majority of confirmed rotavirus cases (13/17, 76.5%) were not eligible for immunisation given their age at the time that the vaccine was introduced. Of the four vaccine-eligible cases, three had received three doses and one had received no doses (Table 4).

Table 4. Number of doses of rotavirus vaccine received by confirmed rotavirus case aged under 5 years, sentinel surveillance hospitals, 2016

Number of doses eligible for	Number of doses received (% of all cases)				Total
	1	2	3	0	
1	0	0	0	0	0
2	0	0	0	1 (5.9)	1 (5.9)
3	0	0	3 (17.6)	0	3 (17.6)
Not eligible	0	0	0	13 (76.5)	13 (76.5)
Total	**0**	**0**	**3 (17.6)**	**14 (82.4)**	**17 (100)**

LABORATORY SURVEILLANCE

Non-sentinel surveillance

In 2016, ESR received 204 samples for genotyping that were not part of the sentinel hospital-based surveillance. Table 5 shows the laboratories that submitted faecal samples to ESR that were rotavirus antigen-positive or indeterminate by the laboratory's screening assay. Samples were from people of all ages, although most (154/207, 74.4%) were from children aged under 5 years. Of the 204 samples received, 200 were tested for rotavirus using RT-qPCR (four samples had insufficient sample available for testing) and 140 (140/200, 70.0%) samples tested positive.

Table 5. Rotavirus-positive samples submitted to ESR for genotyping, 2016

Submitting laboratory	Number of samples received	Samples tested by RT-qPCR[1]	Rotavirus positive by RT-qPCR	Percent positive by RT-qPCR
SCL[2] Wellington	46	45	45	100.0
Middlemore Hospital	36	34	20	58.8
Labtests NZ	32	31	12	38.7
SCL Hastings	20	20	19	95.0
Waikato Hospital	19	19	19	100.0
Medlab Central	16	16	4	25.0
Pathlab Bay of Plenty	12	12	12	100.0
SCL[2] Kew	11	11	1	9.1
SCL[2] Canterbury	5	5	1	20.0
Dunedin Hospital	4	4	4	100.0
Nelson Hospital	2	2	2	100.0
Laboratory Services Rotorua	1	1	1	100.0
Total	**204**	**200**	**140**	**70.0**

[1] Due to insufficient sample submitted, not all samples received could be tested
[2] SCL – Southern Community Laboratories

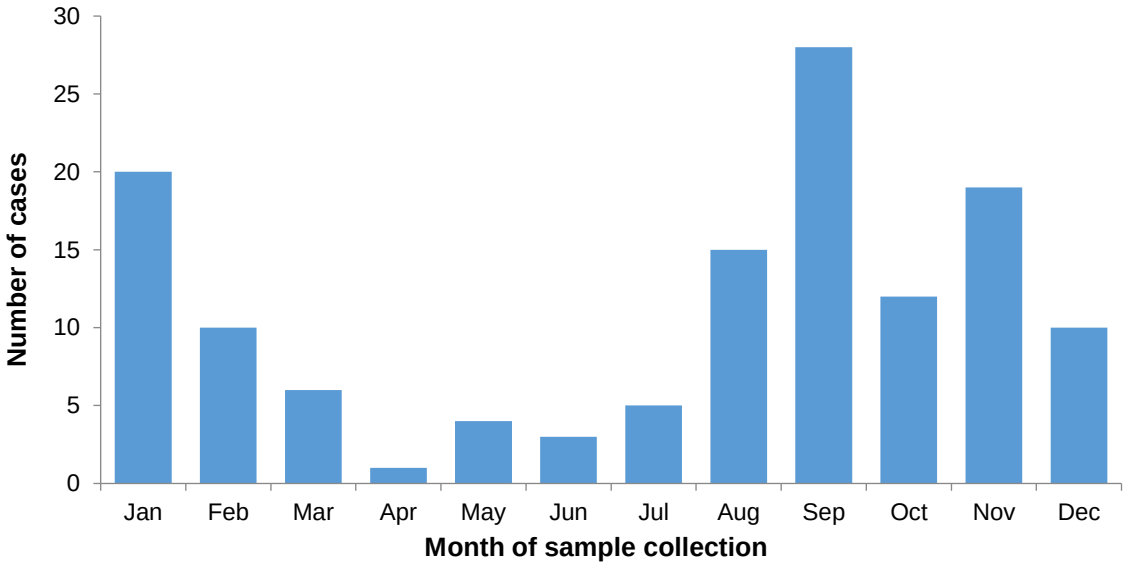
Combined sentinel and non-sentinel laboratory surveillance

Combining the data from sentinel hospital laboratories and other non-sentinel community and hospital laboratories, there were 157 confirmed rotavirus cases using RT-qPCR. The majority (133/157, 84.7%) were aged under 5 years.

Confirmed cases aged under 5 years

Figure 11 and Table 18 (in the appendix) show the number of RT-qPCR-confirmed rotavirus cases in children aged under 5 years by month of sample collection. The typical peak for rotavirus occurred in September (25/133; 18.0%), with another peak in January (20/133, 15.0%). This is in contrast to the national hospital discharge data, which only showed a peak in January (Figure 3).

Figure 11. Number of confirmed rotavirus cases for children aged under 5 years by month of sample collection, 2016



Note: Nine cases had an unknown sample date, therefore the date that the sample was received at ESR has been used

The highest number of confirmed rotavirus cases occurred in children aged 2 years (48, 36.1%). Males (77, 57.9%) accounted for more cases than females (Table 19 in the appendix).

Genotyping – all ages

Of the 157 confirmed rotavirus samples, 153 were confirmed as positive for wild-type rotavirus, and four were identified as containing a component of the RotaTeq® vaccine and therefore referred to as RotaTeq® 'vaccine-like'. All four samples had G1 and P[8] identified and analysis of the VP7 (G) region showed 100% homology with the G1 strain of the vaccine.

G12P[8] was the predominant (87/157, 55.4%) rotavirus genotype followed by G2P[4] (30/157, 19.1%) (Table 6). The majority (133/157, 84.7%) of the genotyped samples were from cases aged under 5 years.

Table 6. Genotype distribution, 2016

Genotype	Number	Percent
G12P[8]	87	55.4
G2P[4]	30	19.1
G3P[8]	15	9.6
G1P[8]	7	4.5
G9P[8]	7	4.5
G1P[8] vaccine-like	4	2.5
G6P[14]	3	1.9
G3P[9]	1	0.6
G8P[14]	1	0.6
G10P[14]	1	0.6
G12P[6]	1	0.6
Total	**157**	**100.0**

Table 7 shows the genotype distribution by vaccination status for all ages. Thirty-nine (24.8%) genotyped samples were from fully immunised children. The majority of the genotypes from fully immunised children were completely or partially the same as the RotaTeq® vaccine types (G1, G2, G3, G4 and P[8]), with the exceptions being G6P[14], G8P[14], G10P[14], and G12[P6].

For the three fully immunised children whose samples were confirmed as rotavirus-positive through the sentinel hospital-based surveillance (Table 4), the genotypes were G12P[8] (2 cases) and G3P[8].

Table 7. Genotype distribution by vaccination status, 2016

Genotype	Fully immunised[1]		Partially immunised		Not immunised	
	Number	Percent[2]	Number	Percent[2]	Number	Percent[2]
G12P[8]	24	61.5	3	50.0	60	53.6
G2P[4]	7	17.9	0	0.0	23	20.5
G3P[8]	3	7.7	1	16.7	11	9.8
G1P[8]	0	0.0	0	0.0	7	6.3
G9P[8]	3	7.7	0	0.0	4	3.6
G1P[8] vaccine-like	0	0.0	2	33.3	2	1.8
G6P[14]	1	2.6	0	0.0	2	1.8
G3P[9]	0	0.0	0	0.0	1	0.9
G8P[14]	1	2.6	0	0.0	0	0.0
G10P[14]	0	0.0	0	0.0	1	0.9
G12P[6]	0	0.0	0	0.0	1	0.9
Total	**39**	**100.0**	**6**	**100.0**	**112**	**100.0**

[1] Fully immunised = three doses (regardless of age)

[2] Percent of column total

DISCUSSION

Vaccine coverage and choice

Rotavirus vaccination was included in the national immunisation schedule on 1 July 2014 using the RotaTeq® vaccine. By the end of 2016, children aged up to 2½ years would have been eligible to receive the rotavirus vaccine, and coverage for children aged 8 months was reported as 88%. This compares with vaccination coverage for all other age-appropriate vaccinations (not including rotavirus) at 8 months of 93%.

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 [10, 11]. It was on this basis that rotavirus vaccines were introduced. RotaTeq® is a live attenuated pentavalent vaccine, consisting of five (G1, G2, G3, G4 and P[8]) human-bovine (WC3) reassortant rotaviruses. The bovine strain, WC3, does not replicate well in humans, therefore, RotaTeq® relies on each reassortant raising neutralising antibodies against the specific rotavirus types in the vaccine. By contrast, Rotarix®, based on a monovalent human G1P[8] strain, does replicate well in humans and provides protection similar to natural infection, with repeated infections giving cross-protection against most other serotypes [10]. 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 [10, 12-15].

On 1 July 2017, the funded rotavirus vaccine was changed from RotaTeq® to Rotarix®. Vaccine effectiveness should persist, but ongoing laboratory surveillance will be important to ensure adequate protection through the chosen vaccine, particularly as vaccine protection against newly emerging genotypes is not well known [10].

Epidemiology

The average annual hospitalisation rate for rotavirus for 2010–2014 was 215 per 100,000, varying by DHB from 57 to 427 per 100,000 (Table 12). This decreased to 24 per 100,000 in 2016, varying by DHB from 0 to 69 per 100,000. Many laboratories stopped routinely testing for rotavirus following the introduction of the vaccine, therefore rates may not be directly comparable with previous years.

As expected, coding practices notwithstanding, it appears that the vaccine has been effective in decreasing the most severe rotavirus disease that resulted in hospitalisation in children under 5 years. Significant disparities by socioeconomic deprivation remain, with most hospitalised cases coming from quintiles 4 and 5 (Figure 6, Table 11). Vaccination appears to have changed the age distribution, with the highest hospitalisation rate in children aged 2 years in 2016, whereas in previous years the highest rates were in those (now vaccinated) aged 1 year and less than 1 year (Table 9).

Rotavirus hospitalisations typically follow a cyclical pattern, with peaks every 4–5 years prior to the introduction of the vaccine. The decline in 2015 was marked and data for 2016 show a further decline in rotavirus hospitalisation rates. Vaccine introduction seems to have influenced the seasonality of the virus with peak hospitalisation rates for 2015 and 2016 occurring in summer months in contrast with the prior spring/winter peaks.

Vaccine breakthrough cases

A total of 39 samples from fully immunised children were confirmed as rotavirus by RT-qPCR at ESR and genotyped. Three samples were from fully immunised children identified through the sentinel hospital-based surveillance, however the hospitalisation status and severity of disease of the remaining 36 cases is unknown.

RotaTeq® was shown in clinical trials to be more effective against severe rotavirus gastroenteritis than all rotavirus gastroenteritis within two years of follow-up, with 98% vaccine efficacy against severe disease and 68% against milder disease [16]. It is likely than many samples from fully immunised children were sent by community-based rather than hospital laboratories and therefore from children with a milder form of rotavirus infection who are less likely to be protected by vaccination [17].

Genotyping

Genotype G12P[8] was the predominant type identified in 2016, accounting for 55% of samples that were genotyped (Table 6). This is an increase from 2015 when G12P[8] accounted for 48% of genotyped samples. An increase in the proportion of G12P[8] rotaviruses has been seen in a range of countries over the last five years; with examples from before (UK [18]), after (US [19], Australia [20], UK [18]) and in the absence of (Spain, the Netherlands [18]) a universal rotavirus vaccination programme. As New Zealand changes from RotaTeq® to Rotarix® it will be important to monitor the impact on G12P[8].

G2P[4] was the second most common genotype identified (19% of genotyped samples) in 2016. By contrast, no G2P[4] rotaviruses were identified in 2015. The 2015 EuroRotaNet annual report noted a shift towards a greater proportion of G2P[4] type rotaviruses in 2014/15 in countries newly introducing a vaccination programme (Germany and the UK) [18]. The overall proportion of G2P[4] in Europe for 2014/15 was 13%.

G6P[14] was identified in three samples in 2016, increasing from one in 2015. This type is seldom reported in the published literature, although another P[14] virus (G8P[14]), was identified in a New Zealand study conducted in 2005/06 [21].

Two vaccine-like strains (containing the bovine WC3 component of the vaccine) were identified in children who had not been vaccinated. The presence of the vaccine component in these two cases could be due to a reassortant of two vaccine strains, or a reassortant of a vaccine strain and a wild-type strain [22]. Further sequence analysis would be required for further characterisation of the strains. Most immunocompetent children will shed rotavirus from

a natural rotavirus infection for 7–10 days, with one third of children shedding for up to 21 days. Viral shedding after RotaTeq® immunisation occurs in about 9% of children after the first dose and then rarely after the second and third doses [23]. This would suggest that the source of the virus in the two unvaccinated children could be due horizontal transmission from a recently vaccinated child, as has been reported to occur between siblings elsewhere [24]. Another possible but unlikely source is from a reassortant virus circulating in the community [25].

Recent systematic reviews and meta-analyses report that vaccine introduction has not resulted in any consistent selective pressure of circulating rotavirus types [26, 27]. Both the RotaTeq® and Rotarix® vaccines are effective against diverse rotavirus types and are highly effective against severe rotavirus disease [28-30]. 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 [27, 31].

Screening tests

The diagnostic procedures and testing eligibility for rotavirus screening differ among laboratories. Further evaluation of the effect of lower specificity on some rotavirus diagnostics may be warranted, given the low prevalence of rotaviruses in the two years since the introduction of the vaccine in mid-2014.

Limitations

Surveillance for rotavirus infections began only after the introduction of the rotavirus vaccine into the national immunisation schedule. We relied on routinely collected hospitalisation data, sentinel hospital data, and laboratory data to demonstrate the impact of the vaccine on rotavirus hospitalisations and genotypes. The data are likely to be incomplete due to varying testing practices, hospital coding issues, and low numbers of cases identified through the sentinel hospital surveillance. Nevertheless, there is clear evidence of vaccine effectiveness.

Of the 722 gastroenteritis cases that were identified through the sentinel surveillance, only 17 (2.4%) were identified as rotavirus-positive. The low number of cases identified has meant that sentinel based surveillance has been discontinued in 2017 and future surveillance will be based on national hospital discharge data and genotyping from referred samples.

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 57,000 rotaviruses between 2006 and 2015 [18].

Conclusion

This report presents the change in hospitalisations and the distribution of genotypes following rotavirus vaccine introduction, using data from hospital discharges, sentinel hospital surveillance and laboratory findings. Despite limitations in the data, there has been a significant decrease in rotavirus infections since a vaccine was introduced in mid-2014.

On 1 July 2017, the rotavirus vaccine used in the national immunisation schedule was changed from RotaTeq® to Rotarix®. Continued surveillance of rotavirus hospitalisations and laboratory genotyping will be required to monitor trends in severe rotavirus infection and detect any changes in circulating rotavirus genotypes.

APPENDIX

DATA TABLES

Table 8. Rotavirus vaccine coverage at age 8 months by quarter, October 2014–December 2016

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%
March 2016	86.9%	85.8%	90.1%	86.3%
June 2016	86.5%	84.4%	91.4%	85.5%
September 2016	87.0%	85.4%	91.7%	86.6%
December 2016	88.2%	85.8%	93.8%	87.7%

[1] Rotavirus vaccination was added into the national immunisation schedule on 1 July 2014

Table 9. Number and rate of rotavirus hospital discharges for children aged under 5 years by age, 2010–2016

Age	2010		2011		2012		2013		2014		2015		2016	
	No	Rate[1]	No	Rate[1]	No	Rate[1]	No	Rate[1]	No	Rate[1]	No	Rate[1]	No	Rate[1]
<1 year	292	452.5	246	391.7	202	330.1	146	242.3	227	385.5	30	50.8	17	28.7
1 year	319	498.8	228	353.4	255	406.8	209	340.6	313	516.5	34	57.2	17	28.4
2 years	150	232.9	96	150.4	109	169.7	93	148.7	146	236.3	20	32.7	26	43.2
3 years	45	72.4	43	66.9	36	56.6	38	59.1	61	96.9	10	16.0	10	16.1
4 years	16	27.0	11	17.7	21	32.8	24	37.8	23	35.6	5	7.9	4	-

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

Table 10. Number and rate of rotavirus hospital discharges for children aged under 5 years by ethnic group, 2010–2016

Ethnic group	2010		2011		2012		2013		2014		2015		2016	
	No.	Rate[1]	No.	Rate[1]	No.	Rate[1]	No.	Rate[1]	No.	Rate[1]	No.	Rate[1]	No.	Rate[1]
Māori	231	272.8	183	214.0	173	203.4	118	140.4	205	246.4	311	37.6	23	28.0
Pacific peoples	85	274.5	95	303.8	68	218.6	67	218.0	81	266.2	10	33.2	10	33.3
Asian	72	192.0	44	116.2	66	175.2	68	182.7	88	238.9	20	54.8	15	41.3
MELAA[2]	15	333.7	14	308.4	16	354.4	11	246.6	15	339.7	2	-	3	-
European / Other	417	266.1	288	182.0	300	190.6	244	158.2	380	246.9	36	23.6	59	38.9

[1] Rate per 100,000 population. Where there were fewer than five cases in any category a rate has not been calculated.
[2] MELAA = Middle Eastern/Latin American/African

Table 11. Number and rate of rotavirus hospital discharges for children aged under 5 years by socioeconomic deprivation, 2010–2014 average, 2015 and 2016

NZDep 2013 quintile	2010–2014 average				2015				2016			
	No	Rate[1]	95% CI	P-value[2]	No	Rate[1]	95% CI	P-value[2]	No	Rate[1]	95% CI	P-value[2]
1	83	151.6	118.9–184.2	-	17	31.8	16.7–47.0	-	6	11.3	2.3–20.3	-
2	78	136.0	105.8–166.2	0.5	11	19.7	8.0–31.3	0.21	6	10.8	2.2–19.4	0.94
3	112	187.3	152.6–222.0	0.1	10	17.2	6.5–27.8	0.12	10	17.2	6.5–27.9	0.41
4	158	251.8	212.5–291.0	<0.01	22	36.0	20.9–51.0	0.71	19	31.2	17.2–45.2	0.02
5	238	301.3	263.0–339.6	<0.01	39	50.7	34.8–66.5	0.11	33	43.0	28.3–57.7	<0.01

[1] Rate per 100,000 population.
[2] Two-tailed test with quintile 1 as the reference value

Table 12. Number and rate of rotavirus hospital discharges for children aged under 5 years by DHB, 2010–2014 average, 2015 and 2016

DHB	2010–2014 average		2015		2016	
	Number	Rate[1]	Number	Rate[1]	Number	Rate[1]
Northland	30	260.9	0	0.0	2	-
Waitemata	87	222.2	16	40.3	6	15.0
Auckland	51	173.0	19	63.1	6	20.2
Counties Manukau	72	169.4	26	62.4	19	45.5
Waikato	75	268.5	3	-	19	68.6
Lakes	24	298.0	1	-	3	-
Bay of Plenty	63	427.0	7	47.5	3	-
Tairawhiti	15	381.3	1	-	1	-
Taranaki	16	200.3	4	-	0	0.0
Hawke's Bay	38	330.8	0	0.0	5	45.4
Whanganui	11	263.5	2	-	0	0.0
MidCentral	21	178.6	1	-	1	-
Hutt Valley	39	368.7	0	0.0	4	-
Capital & Coast	42	219.4	3	-	1	-
Wairarapa	10	352.4	0	0.0	1	-
Nelson Marlborough	12	136.4	0	0.0	1	-
West Coast	4	-	0	0.0	0	0.0
Canterbury	18	56.8	10	31.5	2	-
South Canterbury	4	-	2	-	0	0.0
Southern	38	199.9	4	-	0	0.0
Total	**670**	**215.4**	**99**	**32.4**	**74**	**24.3**

[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.

Table 13. Number of confirmed rotavirus cases for children aged under 5 years by month, sentinel surveillance hospitals, 2016

Month	Hospital			
	Kidz First	Hutt	Wellington	Christchurch
January	4	0	0	0
February	2	0	0	0
March	1	0	0	0
April	0	0	0	0
May	0	0	0	0
June	0	0	0	0
July	0	1	0	0
August	1	1	1	0
September	2	0	0	0
October	1	0	0	0
November	3	0	0	0
December	0	0	0	0
Total	**14**	**2**	**1**	**0**

Table 14. Number of confirmed rotavirus cases for children aged under 5 years by age, sentinel surveillance hospitals, 2016

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

Table 15. Number of confirmed rotavirus cases for children aged under 5 years by ethnicity, sentinel surveillance hospitals, 2016

Ethnic group	Number
Māori	4
Pacific peoples	4
Asian	6
MELAA[1]	1
European/Other	2

[1] MELAA = Middle Eastern/Latin American/African

Table 16. Number of confirmed rotavirus cases for children aged under 5 years by socioeconomic deprivation, sentinel surveillance hospitals, 2016

NZDep2013 quintile	Number
1	3
2	1
3	0
4	2
5	11

Table 17. Symptoms and severity of confirmed rotavirus-positive cases in children aged under 5 years, sentinel surveillance hospitals, 2016

Severity measure	Number	Percent[1]
Vomiting	16	100.0
Diarrhoea	16	100.0
Dehydrated[2]	3	18.8
Nasogastric intubation	3	18.8
Neurological impairment	0	0.0
Associated febrile seizures	0	0.0
Admitted to ICU	0	0.0
Died	0	0.0

[1] Percent of cases where information was provided. No severity details were recorded for one case.

[2.] Yes= Moderate/Severe, No= No/Some/Mild

Table 18. Number of RT-qPCR-confirmed rotavirus cases for children aged under 5 years by month, 2016

Month[1]	Non-sentinel surveillance	Sentinel surveillance	Total
January	17	3	20
February	7	3	10
March	5	1	6
April	1	0	1
May	4	0	4
June	3	0	3
July	4	1	5
August	12	3	15
September	26	2	28
October	11	1	12
November	16	3	19
December	10	0	10
Total	**116**	**17**	**133**

[1] Month of sample collection or date received at ESR if sample date unknown

Table 19. Number of RT-qPCR-confirmed rotavirus cases for children aged under 5 years by age and gender, 2016

Age	Female	Male	Total	Percent[1]
< 1 year	9	7	16	12.0
1 year	12	24	36	27.1
2 years	20	28	48	36.1
3 years	14	14	28	21.1
4 years	1	4	5	3.8
Total	**56**	**77**	**133**	**100**

[1] Percent of the total number of confirmed rotavirus cases aged <5 years

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 acid was extracted from 200 µl of the supernatant using the High Pure® Viral Nucleic Acid Extraction Kit (Roche Molecular Biochemicals Ltd., Mannheim, Germany). Viral nucleic acid was stored at -80 °C until RT-qPCR analysis.

A one-step RT-qPCR method, using the primers and probe and following the PCR parameters described by Pang, Lee, Boroumandet al [32], was performed using the Invitrogen Superscript III One-Step System (Invitrogen, Carlsbad, CA, USA). 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 [20]. The G and P genotype of each RT-qPCR confirmed rotavirus-positive sample was determined by analysis of VP7 and VP4 respectively. 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 VP7 typing, certain samples, including those where GI, G2, G3 and G4 types were identified, were subjected to VP6 typing. VP6 typing identifies if the bovine-WC3 backbone of the RotaTeq® vaccine is present in the sample.

CASE REPORT FORMS FOR SENTINEL HOSPITAL-BASED SURVEILLANCE

Form 1–used in Kidz First Children's Hospital until April 2016

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

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

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 _____

Form 2–used by all sentinel hospital sites from April 2016

Confidential

Case Report Form

Record ID _____

Admin details

Hospital site
- ◯ KidzFirst
- ◯ Wellington
- ◯ Christchurch
- ◯ Hutt

Encounter number (main) _____

Encounter number (additional) _____

Nurse _____
(Enter first name)

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

Verbal Consent
◯ Yes
◯ No

Immunisation details

Immunised against rotavirus?
◯ Yes
◯ No
◯ Unknown

Vaccine
◯ Rotarix
◯ RotaTeq

No of doses _____

Immunisation date 1 _____

Immunisation date 2 _____

Immunisation date 3 _____

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 - rotavirus positive cases only

Maximum temperature recorded (oC) _____
(1 decimal place)

Temperature Method
◯ Oral
◯ Rectal
◯ Axillary
◯ Tympanic

Vomiting
◯ Yes
◯ No

Maximum number of vomiting episodes per day _____
(Leave blank if 'unknown')

Vomiting duration (days) _____

Diarrhoea	◯ Yes ◯ No
Maximum number of diarrhoea episodes per day	_____ (Leave blank if 'unknown')
Diarrhoea duration (days)	_____
Number of liquid stools in the 24 hours prior to admission	_____

Severity and complications - rotavirus positive case only

Dehydration	◯ No ◯ Some ◯ Severe
Dehydration treatment	◯ Fluids ◯ Oral rehydration salts (ORS) solution ◯ IV therapy
Nasogastric intubation	◯ Yes ◯ No
Admitted to ICU	◯ Yes ◯ No
Died	◯ Yes ◯ No
Date of death	_____
Other severe outcome (eg. neurological impairment, febrile seizures)	◯ Yes ◯ No
Specify	_____

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