The National Childhood Immunisation Coverage Survey 2005

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Foreword

Vaccine-preventable diseases have a significant impact on health, and immunisation programmes are considered to be one of the most cost-effective public health interventions. However, their effectiveness in preventing epidemics is dependent on obtaining vaccination coverage levels of around 90 to 95%. It is therefore crucial to know national coverage levels and any inequalities in coverage when planning immunisation programmes, to help target vulnerable groups, and for predicting the likelihood of vaccine-preventable disease epidemics.

In New Zealand the last national survey on coverage levels was undertaken in 1991/92. No other robust estimates of coverage have been available until this National Childhood Immunisation Coverage Survey was undertaken in 2005. The survey involved interviewing the caregivers of 1563 children throughout the country, and the results provide good estimates of the level of vaccination coverage for two- to three-year-olds in New Zealand. This information can be used to assess the extent to which the National Immunisation Programme is succeeding in gaining greater and more equitable immunisation coverage for our children.

Ensuring access to appropriate child health care services, including Well Child and family health care and immunisation, is one of the 13 priority population health objectives in the New Zealand Health Strategy. Knowledge about coverage levels is crucial to achieving this objective. The Government has committed to reducing inequalities in health status, focusing on Māori, Pacific, and low-income New Zealanders, and information about inequalities in immunisation coverage is essential for planning to eliminate any disparities. In addition, immunisation for Māori is one of the eight Māori health gain priority areas.

The 2005 National Childhood Immunisation Coverage Survey highlights significantly lower coverage for those children identifying as Māori compared with European/Other. The Government has acknowledged the importance of prioritising Māori health gain and development by identifying the need to reduce and eventually eliminate health inequalities that negatively affect Māori, so improving the coverage level for tamariki Māori is a priority. By focusing on and working alongside Māori there is the potential not only to improve coverage for Māori, but also for the whole population. The results from this survey can be used to provide the impetus and baseline measures necessary to further the aim of increased and more equitable vaccination coverage levels for New Zealand children.

Comments on this report are welcome and should be sent to Public Health Intelligence, Public Health Directorate, Ministry of Health, PO Box 5013, Wellington.

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Executive Summary

The National Childhood Immunisation Coverage Survey was undertaken from January to March 2005. The survey involved collecting demographic data on two- to three-year-old children and their principal caregivers, and information on the completeness of the child's vaccinations. Data were also collected on the reasons for incomplete immunisation and the principal caregiver's attitudes towards and understanding of childhood immunisation.

The aim of this survey was to provide a baseline measure of coverage levels for the National Immunisation Programme, and to measure any changes since the previous national coverage survey conducted in 1991/92 by the then New Zealand Communicable Disease Centre. The information gathered on caregiver attitudes to immunisation can also inform strategies designed to improve coverage levels.

This Occasional Bulletin presents the results of this survey and some background information on the history of monitoring vaccination coverage levels in New Zealand, why monitoring is important, and what effect it could have on coverage levels.

The survey methodology was based on the New Zealand national coverage survey in 1991/92 (Department of Health 1992). The difference in the 2005 survey was the ability to perform robust ethnic analysis to highlight any ethnic inequalities. The survey had a response rate of 84% and involved face-to-face interviews with 1563 caregiver respondents. All results presented are the weighted results, designed to provide population estimates of coverage levels and reasons for late or incomplete immunisation. The statistical packages SAS 9.1 and SUDAAN 9.0.1 were used to calculate results and their associated variance, presented as 95% confidence intervals. Prioritised ethnicity has been used for all analyses.

The results show significant demographic differences between the ethnic groups. In particular, children of Māori caregivers were significantly more likely to have moved household on more than two occasions since birth compared with children of European/Other and Asian caregivers, and Māori caregivers were significantly more likely to be a caregiver living alone compared with all other ethnic groups.

Immunisation coverage levels are presented at different end points: age one year, age two years, at the time of the survey, and on time according to the recommended ages in the National Immunisation Schedule. The overall coverage level for being fully immunised at age two years was 77.4% (95% confidence interval 75.3–79.5), compared with less than 60% from the 1991/92 survey.[1] Māori children were significantly less likely to be fully immunised at age two years (69.0%; 63.7–74.3) than European/Other children (80.1%; 77.4–82.9). Pacific children had the highest coverage level of all ethnic groups, although the difference was not statistically significant from that of the European/Other ethnic group.

[1] Although covering all of New Zealand, this survey was conducted at a regional level and as a result, no specific national coverage estimate is available.

Coverage levels significantly decreased for the 15-month vaccines compared with vaccines given in the first year of life, and with consecutive doses of individual vaccines. On-time vaccination for individual vaccine doses was significantly lower than for the other coverage end points.

Results are also presented by four regional health areas and by District Health Board (DHB) where possible. There was little significant difference between coverage levels among the four regions, but there was a north to south trend for increasing levels of coverage. Although there were significant differences between DHB coverage levels, caution needs to be used interpreting these results due to small numbers and wide confidence intervals.

Concern about the risk associated with immunisation was the most frequently cited reason for missed vaccinations. This was also the most common reason given by Māori and European/Other caregivers, and for all health regions except the Southern region. Over 50% (52.4%; 49.6–55.3) of caregivers believe immunisation can cause serious effects, although nearly 80% (76.7%; 74.4–78.9) believe serious side-effects are rare. Use of a different immunisation schedule and medical reasons were also among the more common reasons for missed vaccinations, although the only significant finding was for the use of a different immunisation schedule for children of Asian caregivers. This part of the analysis did not provide an explanation for ethnic differences in coverage, particularly as the results are based on small numbers.

A multivariable model using logistic regression was used to examine risk factors for incomplete immunisation at age two years. The significant findings were a decreased odds ratio for fully immunised status at age two years in children from households moving on two or more occasions since the birth of the child (odds ratio (OR) 0.46; 0.33–0.64), and the child's principal caregiver identifying as Māori (OR 0.60; 0.41–0.87). The other variables included in the model were: household income, caregiver age, caregiver qualifications, and caregiver living status.

The 2005 survey shows an improvement in childhood immunisation coverage from the previous national survey in 1991/92, but there are still significant ethnic disparities in coverage for Māori children. Although the inequalities between Māori and the total population have decreased in both relative and absolute terms from 1991/92 to 2005, equality in ethnic coverage is one of the strategic aims for the National Immunisation Programme. Furthermore, overall coverage needs to improve to reach the target of 95%, the level required to prevent outbreaks of diseases such as measles.

Strategies need to be devised that prioritise improving immunisation coverage for Māori in particular, and the population as a whole. The results from this survey cannot provide answers for why there are persisting disparities. However, the survey does serve to highlight the inequalities in coverage and provides a baseline measure from which interventions designed to improve coverage can be assessed for their effectiveness.

A function of the National Immunisation Register will be to provide ongoing monitoring of coverage levels that can be compared to this snapshot of coverage from 2005. It is hoped that the Register, the implementation of primary health organisations, and DHBs' responsibility for their populations will all contribute to further improvement in coverage. It will be essential to work alongside the Māori community to develop successful interventions to improve coverage for Māori. The high coverage level obtained by DHBs with higher proportions of Māori ethnicity shows that this is an achievable aim.

Introduction

In 1991/92 the New Zealand Communicable Disease Centre conducted a childhood immunisation coverage survey using an approach largely informed by the World Health Organization Programme on Immunisation (Department of Health 1992). This report presents the results of a survey designed to use a similar methodology, but this time with greater emphasis on obtaining more robust estimates for Māori and Pacific ethnic groups.

The aims of the National Childhood Immunisation Coverage Survey 2005 were to:

- measure the national immunisation coverage of two- to three-year-olds as a baseline for the National Immunisation Programme
- measure any change in immunisation coverage since the 1991/92 national survey and identify any inequalities in coverage
- examine caregivers' attitudes to immunisation.

The National Immunisation Programme within the Public Health Directorate of the Ministry of Health leads immunisation policy and planning in New Zealand. The functions of the National Immunisation Programme include:

- implementation of the immunisation strategy
- policy development and oversight of standards
- securing adequate funding levels
- service development and monitoring
- vaccine purchase and distribution
- oversight of communication issues
- directing research to complement the strategic direction.

The Public Health Directorate operations group oversees and co-ordinates national service contracts and thereby maintains relationships with District Health Boards (DHBs), primary care providers and other key stakeholders in order to implement national policies successfully. The National Immunisation Programme sets and monitors immunisation targets and quality indicators for DHBs and primary health organisations (PHOs), which are essential for gaining improvements in immunisation coverage.

This 2005 survey provides a robust estimate of the current population immunisation coverage level for two- to three-year-olds. The results of the survey give accurate population measures of immunisation coverage, which are fundamental to highlighting areas of immunisation need in New Zealand and for monitoring any trends in coverage since 1992. In addition, the coverage levels can be used to estimate the effectiveness of the recently implemented National Immunisation Register in improving immunisation coverage, and to evaluate other strategies introduced to improve coverage levels.

Analysis of the coverage survey results will be widely disseminated by the Ministry of Health to DHBs, primary care providers, other immunisation service providers, and the general public.

Background

The importance of knowing immunisation coverage levels

Immunisation coverage refers to information on the proportion of children who have received specific vaccines or are up to date with the recommended vaccine schedule (Ministry of Health 2002). This information is essential for:

- planning immunisation programmes, and especially for identifying vulnerable groups or areas that require targeting of increased resources
- assessing the acceptability of a programme
- predicting likely vaccine-preventable disease epidemics
- helping to measure vaccine efficacy and monitoring vaccine-associated adverse events (Ministry of Health 2002).

Vaccine-preventable diseases have a significant impact on health. Approximately 500 deaths per year in the United States of America (USA) are attributable to vaccine-preventable diseases of childhood[2] (Shefer et al 1999). Immunisation is often cited as being one of the most cost-effective public health interventions (CDC 1999), but effective immunisation requires population coverage levels of 90 to 95%, depending on the vaccine-preventable disease; for example, Morbilli measles requires 95% coverage (Peltola et al 1994).

Even if national immunisation coverage levels are sufficiently high to block disease transmission, pockets of susceptibility may act as potential reservoirs of infection. It is therefore essential to know if under-vaccination is a problem in specific population groups (Rosenthal et al 2004), which involves determining if there are any inequalities in coverage levels. Coverage levels are also required for evaluating strategies introduced to address these inequalities in coverage.

Childhood immunisation coverage in New Zealand

The World Health Organization (WHO)/UNICEF ranking for immunisation coverage in New Zealand in 2003 was 121 out of 192 countries (WHO 2005). New Zealand has benefited less from the improvements to population health made possible by high immunisation coverage than many other countries (Petousis-Harris, Turner et al 2004). In contrast, Australia and the USA improved their coverage during the 1990s, unlike New Zealand (Petousis-Harris, Goodyear-Smith et al 2004).[3] Although immunisation in New Zealand has eliminated wild polio and has controlled tetanus and diphtheria, we still experience epidemics of measles, pertussis and rubella. In addition, although the occurrence of *Haemophilus influenzae* type b disease has been reduced by over 90%, this disease has been virtually eliminated in other countries (Turner et al 2000).

[2] This analysis has not been done for New Zealand, the closest analysis being the burden of all infectious disease in New Zealand.

[3] See section 'Strategies used to improve immunisation coverage' for further information.

Historically, New Zealand has had an incomplete record of measuring childhood vaccination coverage levels. Prior to the current survey, the last national coverage survey in New Zealand was undertaken in 1991/92. The 1991/92 survey showed an immunisation coverage level of less than 60% for full immunisation at age two years, and lower coverage for both Māori and Pacific populations[4] (Department of Health 1992). In 1996 North Health repeated the survey for their region using the same methodology to assess immunisation coverage, and although coverage had improved to 63% this was not significantly better than for the North Regional Health Authority coverage obtained in the 1991/92 survey (Lennon et al 1997). Māori (44.6%) and Pacific children (53.1%) both had significantly lower coverage than European/Other children (72.3%) in the North Health 1996 survey.

After the 1991/92 survey, national estimates of coverage were based on immunisation benefit claim data and information from capitated medical practices, with denominators based on census data. However, these estimates were subject to data quality problems and were not believed to be an accurate indication of national coverage levels (Turner et al 2000). The conclusion from the paper by Turner et al was that there was no evidence from the benefit claim data of any improvement in coverage from 1996 to 1999.

In addition to these surveys and coverage estimates based on immunisation benefit claim data, other sources of data, such as GP and Well Child records, have been used to assess coverage. For example, high immunisation coverage levels have been reported for age two years in Wairoa (Janes et al 2001); levels of 92.4% have been reported for age two years in the Rotorua General Practice Group (Pert 1999); and in the cohort of children in the Plunket National Child Health Study in 1990/91 the coverage level at age two years was 83.3% (Essex et al 1995).[5] It should be noted, however, that coverage levels will vary according to which population is examined (eg, national coverage rates may be lower than regional coverage levels, as national coverage does not reflect the success of local initiatives) and the source of the data used to calculate the coverage level.

National immunisation coverage targets were devised for the Public Health Commission's advice to the Minister of Health in 1993/94. A target of 85% full immunisation at age two years was recommended by 1997, with coverage for Māori children equalling the non-Māori coverage level, and then subsequently 95% coverage for all by 2000 (Ministry of Health 1998). These recommendations were incorporated into the National Immunisation Strategy, Immunisation 2000, launched in 1996. A report from the National Health Committee in 1999 recommended revising the target to 90% for all groups by 2003 (National Health Committee 1999). The Ministry of Health document *Immunisation in New Zealand: Strategic directions 2003–2006* set a 95% coverage target for 2005 (Ministry of Health 2003). Despite these targets being set, no

[4] Figures for Māori and Pacific peoples were not presented in the 1992 report but were presented in subsequent articles without confidence intervals because the survey was not designed to provide good estimates for ethnic coverage levels. Caution should therefore be exercised when using these figures.

[5] The figures for coverage from the Plunket study were criticised for not including the children lost to Plunket follow-up, who will be the children at greatest risk for missing out on immunisation (Gray 1995).

accurate evaluation of how national coverage levels compared with these recommended target levels was undertaken until this current survey.

Reasons for incomplete immunisation coverage

The reasons for incomplete immunisation can be divided into four main categories:

- provider practice
- caregiver practice
- demographics or social determinants
- national immunisation support systems.

Conscientious objectors to immunisation usually represent only a minority of those children who are not fully immunised.[6]

Provider practice

Low immunisation coverage levels are often more closely related to the characteristics of the medical provider than to the attributes of the family and child (Jelleyman and Ure 2004; Turner 2004). International research has shown that health provider knowledge about immunisation is an important factor in vaccine uptake (Peckham et al 1989; Taylor et al 1997; Zimmerman et al 1997). A telephone survey of New Zealand GPs in 2004 demonstrated a need to address knowledge and resource gaps among family physicians (Petousis-Harris, Goodyear-Smith et al 2004), and Turner has recommended this for all health professionals (Turner 2004). It is important that health providers be clearly able to communicate risk-benefit information for immunisation.

Caregiver practice

Incomplete immunisation can be due to a lack of knowledge and awareness of diseases. This can be complicated by misconceptions about vaccination and vaccination safety affecting confidence in immunisation (Thomas et al 2003; Petousis-Harris, Goodyear-Smith et al 2004). Analysis of the United States Annual National Immunisation Survey from 2001/02 showed that being up to date with vaccinations was associated with caregiver rating of vaccine safety, even after adjustment for demographic variables (Allred et al 2005). Often vaccination may be delayed due to minor concurrent illness in a child that would not have been a contraindication to vaccination. Caregivers can be fearful of vaccine reactions (Petousis-Harris, Boyd et al 2004) and suspicious of government and pharmaceutical industry messages (Thomas et al 2003). National surveys have shown that caregivers place more trust in information from their GP than from pharmaceutical or Ministry of Health-based information (Petousis-Harris et al 2005).

As vaccine-preventable diseases have become less common in New Zealand, the community perceptions of the risks and benefits of immunisation have changed (Ministry of Health 2003). For example, caregivers may believe that illnesses immunised against are not serious risks to health (Hamilton et al 2002).

[6] This proportion has been variously reported, ranging from 1 to 6% of the population (Turner et al 2000; Hull, Lawerence et al 2001).

Demographics or socioeconomic determinants

A number of demographic and socioeconomic factors associated with incomplete vaccination are discussed in the literature. In New Zealand, the 1991/92 regional coverage surveys showed that those children living in a home where the principal source of income was from a benefit, caregivers identifying as Māori, and a child's caregiver not achieving School Certificate were associated with incomplete immunisation, the first of these having the most significant impact (Department of Health 1992). A survey undertaken in Hawke's Bay in 1991 also found that a household with the principal source of income from a benefit had the greatest impact on incomplete immunisation, and that a child identified as Māori, younger mothers (less than 25 years old), and the level of schooling achieved by the household's main income earner were also associated with incomplete vaccination (Stehr-Green et al 1992). In addition, the North Health survey in 1996 showed that high mobility of families was independently associated with under-immunisation (Lennon et al 1997).

High mobility has also been associated with incomplete immunisation in international studies (Bond 1999b). A study of children in Victoria, Australia, identified the following risk factors for incomplete immunisation: single-parent families, parents born overseas and no English spoken at home, parents less than 25 years old, lower family income, higher levels of parental education, and childhood illness or frequent doctor visits (Haynes and Stone 2004). These factors were all supported by a national Australian study using their immunisation register (Hull, Lawerence et al 2001). This study also found that lower maternal education and late birth order or larger families were also associated with incomplete immunisation (Hull, Lawerence et al 2001; Hull, McIntyre et al 2001).

Other international studies have found similar risk factors for under-immunisation (Sharland et al 1997; Gust et al 2004; Shefer et al 1999). The Centers for Disease Control and Prevention (CDC) found that urban and low-income populations were associated with lower immunisation coverage among children aged 19–25 months (CDC 1997, 1998), and this has also been found in the United Kingdom (Sharland et al 1997).

National immunisation support systems

New Zealand GP surveys have identified that a lack of funding to providers is a key area of concern contributing to low immunisation coverage rates (Turner 2004). International studies show that financial and quality support to health professionals and the community, along with integrated information systems, are associated with improved coverage (National Vaccine Advisory Committee 1999).

When comparing the New Zealand coverage level with similar countries there are a number of differences that may explain the lower coverage achieved for New Zealand. Countries achieving better coverage (eg, Australia, the USA) have implemented regular surveillance of vaccine coverage and invested in infrastructure to improve coverage (NCIRS 2005; Briss et al 2000). In New Zealand, prior to 2000 no substantial additional funding was arranged to achieve coverage targets and a surveillance system has only recently been implemented. In a number of studies the strongest predictor for incomplete immunisation was failure to commence the immunisation schedule on time or late vaccinations (Hanna et al 1994; Schluter and Ford 1998; Bond 1999a; Hull, McIntyre et al 2001; Grant 2004), issues that could be addressed by the use of an immunisation register.

Strategies used to improve immunisation coverage

Reviews of evidence-based strategies for improving immunisation coverage have been conducted in the USA (Shefer et al 1999; Briss et al 2000). These reviews used a framework developed by the United States Department of Health and Human Services to assess the strength of evidence (strong, sufficient, expert opinion, insufficient) for the effectiveness of an intervention to improve vaccination coverage, based on design suitability, size of effect, the use of expert opinion, number of studies in the literature, and consistency of effect between studies (Table 1).

Strong evidence was found for client or provider reminder/recall alone, and for using provider feedback and assessment of vaccination coverage information alone. There was sufficient evidence to support the use of vaccination requirements applied to child care or school entry, and the use of home visits. A number of interventions on their own did not show sufficient evidence for improving coverage, but as part of a multi-component intervention they did successfully demonstrate improved coverage. These included the use of provider education, improved time and distance access, alternative settings with other non-vaccine interventions, and clinic-based education. There was insufficient evidence at the time of the review for the use of community education, or incentives for the provider or the client, standing orders for child vaccination, or client-held medical records, although it was thought that some of these could well be proven effective with further research. It is worth noting that this review did not assess cost-effectiveness or other implementation issues.

Table 1: Effectiveness of interventions to improve vaccination coverage

Strong evidence	Sufficient evidence	Insufficient evidence alone but strong/sufficient with multi-component approach	Insufficient evidence
Client reminder/recall	Entry requirements to school/childcare centre	Clinic-based education	Client/family incentives
Reducing cost of vaccination	Home visits	Expanding access	Client-held medical records
Provider reminder/ recall		Provider education	Standing orders
Provider feedback and assessment of coverage		School- and childcare centre-based programmes	Community-wide education

Source: Shefer et al 1999

The success of Australia and the USA in improving vaccination coverage has been attributed to improving the communication of vaccine safety issues and an increased emphasis on supporting providers (National Vaccine Advisory Committee 1999; Lister et al 1999).

National recall systems have also been associated with improved coverage. In Scotland a 2004 study showed that, for certain vaccinations, primary care practices using the national call/recall system had significantly better coverage at age two years (Henderson et al 2004). In Australia, the Australian Childhood Immunisation Register (ACIR) was introduced in 1996, and fully immunised coverage improved from 53% in 1995 to 74.9% in 1997 (Clarkson 2001). Over the period 1997–2000 Australia introduced a plan for increasing immunisation coverage, including monetary incentives for parents, incentives for GPs, a range of educational incentives, school-entry legislation, enhanced research activity and monitoring and evaluation of immunisation targets, and ongoing development of the ACIR (Grant 2004; Hull, Lawerence et al 2001). Immunisation coverage improved to 85% in 2001 (Turner et al 2000), and the latest estimates from the ACIR for 2003 show a coverage level of 91.8% at age two years (NCIRS 2005). Research suggests that tracking and reminder systems significantly improve immunisation coverage and are cost-effective (Davidson et al 2003).

In New Zealand the Ministry of Health recognises that in addition to establishing a vaccine coverage surveillance system (the National Immunisation Register) improvement in vaccination coverage requires:

- a sustainable financing strategy for the National Immunisation Programme
- a focus on workforce development and a recognition of the crucial role played by primary care in vaccine delivery
- improved community and provider support (by improving access to immunisation and the development of effective communication and promotion strategies) (Ministry of Health 2003).

The establishment of PHOs with enrolled populations and their responsibility for immunisation of this population, along with accountability to DHBs, may help to improve immunisation coverage.

It is worth being aware that national coverage levels may not reflect local coverage levels, and in New Zealand there are local initiatives successfully obtaining high levels of coverage (see previous section 'Childhood immunisation coverage in New Zealand'). Within New Zealand, factors that have been identified as contributing to better coverage levels include children staying with the same general practice, reflecting continuity of care (McLeod et al 2001), population stability, patient enrolment and provider co-operation (Janes et al 2001). In addition, practice management software that can manage effective recall systems and the use of a dedicated immunisation co-ordinator with outreach to high-risk children have also been linked with higher levels of coverage (Pert 1999).

A number of reports and papers in New Zealand have provided recommendations for improving immunisation coverage. The recommendations in the report from the 1991/92 national immunisation coverage survey focused on improving education for providers and caregivers relating to contraindications to vaccination and on-time doses (Department of Health 1992). Strategies suggested included improving opportunistic immunisation and the use of alternative settings for vaccine delivery, improving recall systems, and ongoing review of immunisation coverage levels.

In 1999 the National Health Committee produced recommendations for improving funding for the primary care sector and incentives for immunisation in primary care settings, and ensuring all children are enrolled in primary care (Turner et al 2000). They also recommended developing outreach services and targeted health promotion.

Many of these strategies to improve immunisation coverage require reliable coverage information for their development, monitoring and evaluation.

National Immunisation Register

In New Zealand the National Immunisation Register was developed to monitor the immunisation coverage data of infants and children, and was first used for the MeNZB™ campaign.[7] The National Immunisation Register is a computerised system designed to hold immunisation details of all New Zealand children, and works on an 'opt-off' basis. It is designed to measure coverage levels by age, birth cohort, ethnicity and area. However, because no retrospective data will be entered onto the National Immunisation Register, a complete picture of national immunisation coverage will take some time. The National Immunisation Register's functions include provider or client reminders or recalls and information for parents, and it can facilitate co-ordination between services.

[7] A nationwide campaign to deliver a tailor-made vaccine against New Zealand epidemic strain (B:4:P1.7b,4) of group B meningococcal disease to all under-20-year-olds.

The National Immunisation Register can be seen as a tool to achieve immunisation by two years of age for those children not yet fully immunised, such as children from very mobile families or those using multiple primary health care providers (via provider reminders, client reminders and recall, and co-ordination between services). In addition, the National Immunisation Register aids opportunistic vaccination, facilitates referral to outreach services, and helps to target resources more effectively to populations with the lowest immunisation coverage levels (Ministry of Health 2004).

The National Immunisation Register and the National Immunisation Programme are located within the Public Health Directorate of the Ministry of Health. The document *Immunisation in New Zealand: Strategic directions 2003–2006* established implementation priorities for the National Immunisation Programme for this time period (Ministry of Health 2003). These included not only the establishment of the National Immunisation Register, but also the need to reduce inequalities in immunisation coverage and the development of an effective communication and promotion strategy for immunisation. Implementing these strategies requires information about immunisation coverage by area and ethnicity.

Methodology

Background

This survey was funded by the National Immunisation Programme within the Ministry of Health. The National Research Bureau (NRB) was contracted to design and field the survey, with guidance from the National Immunisation Programme and Public Health Intelligence (PHI). NRB's role included designing the sampling methodology (with input from PHI), piloting the questionnaire, obtaining ethical approval, interviewing respondents, processing data, and providing a data set with appropriate documentation to the Ministry of Health. Public Health Intelligence was responsible for the data analysis and publication of the report. Further information on the methodology of the survey and analysis can found in Appendix 1.

Survey methodology

Design requirements

The survey was designed to achieve minimum accuracy level estimates of immunisation coverage of ±3% for national results, ±6% for Māori and ±8% for Pacific peoples. The accuracies are represented by sampling errors in the form of 95% confidence intervals (see section Weighting and data reliability).

Sample frame and selection

The target population was the New Zealand population of children aged two and three years old living in permanent private dwellings. This age group reflects immunisations given one to three years ago, and was chosen because it is comparable with the 1992 survey, and reflects international study design. According to the 2001 New Zealand Census of Population and Dwellings (2001 Census), the target population was approximately 107,000 children.

The primary sampling units of the sample frame were meshblocks (small geographic areas defined by Statistics New Zealand according to the 2001 Census) falling within the geographic coverage of the survey.[8] Exclusions of households from the defined target population (eg, households not located on the main islands of New Zealand) were accounted for in the final estimates via the survey weights. In addition, all meshblocks had to contain nine or more households and a non-zero count of children aged two or three years at the time of the 2001 Census. This restricted the eligible target population (ie, two- to three-year-old children in New Zealand living in permanent private dwellings) to 98.6%.

For the first stage of sampling the meshblocks were divided into two strata:

- stratum 1: meshblocks containing Pacific peoples at a density of 10% or more
- stratum 2: meshblocks containing Pacific peoples at a density of less than 10%.

[8] The geographic coverage of this survey included only households on the North and South Islands (including Waiheke Island) and excluded eligible households on other off-shore islands, on-shore islands, waterways and inlets.

Meshblocks were randomly selected with equal probability of selection from each stratum. However, a higher sampling fraction was chosen for stratum 1 compared to stratum 2, due to the need to obtain a larger proportion of Pacific peoples in the sample than naturally exists in the population. The result was a selection of 150 meshblocks from stratum 1 and 480 meshblocks from stratum 2. The number of meshblocks sampled was based on an expected response rate to the survey of 75%.

The second stage of sampling involved the household selection from within each meshblock. All households in a meshblock were screened for those containing eligible participants, defined as a principal caregiver of a child aged two or three years during the survey period (January to March 2005). A total of 28,780 dwellings were screened. The third stage of sampling involved the selection of one child from all selected eligible dwellings. If more than one eligible child was present within a household, one was selected at random using the Kish grid.

Of the estimated 1851 eligible households, 1563 respondents were successfully interviewed. A number of reasons were given for the inability to interview respondents from selected households (see Appendix 1 for further information). The response rate was calculated by the NRB as 84%.

Interview process

The data were collected by face-to-face interviews using trained interviewers. Interviews were carried out from January 2005 to March 2005. The interview was conducted with the principal caregiver of the child aged two or three years. Interviewers collected information on the demographic characteristics of the child and of the person identified as the principal caregiver for the child. The questionnaire also sought information about the principal caregiver's understanding and perception of vaccine-preventable diseases and immunisation. With the caregiver's consent, medical records were used to confirm the child's vaccination history (*Well Child Tamariki Ora Health Book*, or if not available, GP or hospital records); when consent was not provided or confirmation sources were not available, caregiver recall of vaccination was recorded.

Data from the paper questionnaire were entered electronically without personally identifiable details. Editing and checks of data were undertaken by the NRB and inconsistencies were remedied, if necessary, by returning to the respondent for clarification and correction. Non-response was adjusted for in the weighting estimation, and the survey population was post-stratified to an estimate of the target (benchmark) population.

Weighting and data reliability

Survey weights allow the sample to be used to produce estimates for the entire population, as each child within the survey represents a number of children within the population. Selection weights adjust for the probability of selection, which differs for each child; for example, Māori and Pacific children had a greater chance of selection so that more reliable estimates could be produced. The selection weight is the inverse of the probability of selection.

Weighting was also done to ensure that each stratum was consistent with prioritised ethnicity (three groups prioritised in order: Māori, Pacific and European/Other), and deprivation quintiles were determined by benchmark population counts from the 2001 Census. Although there was no post-stratification adjustment for Asian respondents, this is unlikely to diminish the validity of separate analyses for Asian children. The weighting adjustment also corrects for under-coverage and non-response, and reduces the level of sampling error for variables determined by the benchmark population. Replicate survey weights were also applied to calculate the sampling error.

In addition to sampling errors, various non-sampling errors are possible, such as insufficient coverage of respondents, inadequacies and imperfections in answers provided by respondents, and errors made when coding and processing data. Attempts were made to reduce the impact of non-sampling errors by using a previously employed survey design, testing the survey, questionnaire and processes, and ensuring detailed quality control of procedures and data.

Data analysis methodology

The survey analysis was undertaken using the statistical packages SAS 9.1 and SUDAAN 9.0.1. To calculate coverage levels, the numerator only included those children with written proof of vaccination and the denominator included all 1563 respondents. This represents the most conservative estimate of coverage. For individual doses of vaccine to be analysed as being received by the child, all previous sequential doses of the same vaccine needed to be recorded. Results are presented as coverage levels for individual doses and as up-to-date immunisation for different end points. Coverage levels were calculated for all children at the time of the survey (January to March 2005), at the age of one year and two years old, for children receiving vaccination within four weeks of the schedule's recommended age (on-time vaccination), and on time according to the appropriate interval between sequential doses (on-time interval-adjusted vaccination, so an initially late vaccine did not automatically mean all vaccines were recorded as being given late). The estimation of variance for the coverage levels was calculated using the delete-a-group jack-knife method (see Appendix 1).

Results have been stratified by ethnicity and health region, as well as DHB where possible. Prioritised ethnicity has been used for all analyses. See Appendix 2 for construction of the health regions from DHBs. The health regions were constructed to allow comparisons with the previous national coverage survey in 1991/92. Results by health region are only presented for the measures used in the 1991/92 survey, as these health regions are no longer relevant. Although the survey was not designed to provide robust estimates for Asian ethnicity, there were sufficient numbers of respondents identifying as Asian in the data set to produce estimates with acceptable confidence intervals. Likewise, the survey was not designed to provide robust estimates at the DHB level, but the analysis also looked at trends by DHB. Limited results of the DHB part of the analysis are presented, due to small numbers and wide confidence intervals, making the results unreliable for some DHBs. In general, results based on numerators of fewer than 10 respondents are not presented or are highlighted.

The second part of the analysis used logistic regression to determine the significant factors associated with coverage levels at age two years. Logistic regression with SAS presumes a simple random sample, and for sample survey data it tends to present a false positive result by underestimating the variance. Therefore, it was more appropriate to use SUDAAN, which calculates a more robust coefficient of variance by taking into account the clustered nature of the sample.

Risk factors for coverage levels at age two years were chosen based on the background literature review and what had previously been shown to have a significant effect on coverage level in past studies (including the 1991/92 surveys). In addition, the choice of these risk factors was assessed according to the independent effect on immunisation status at age two years.

The risk factors examined were:

- household income
- principal household income from a benefit
- NZDep2001 quintile
- ethnicity of principal caregiver (Māori versus non-Māori)
- education level of principal caregiver
- number of household moves since birth of child
- age of principal caregiver
- principal caregiver living status (alone versus living with others).

Reference groups were chosen for each risk factor corresponding to the group expected to have the highest coverage level.

Initially all models were fitted with one risk factor (a univariate analysis). To further test the associations of the risk factors with immunisation coverage level at age two years, all significant risk factors were fitted in one model. The model was applied separately for the total survey population, four health regions, and ethnicity of the child (Māori and non-Māori). Results for the total survey population are presented in this survey because there were no significant further findings by applying the model to the different sub-groups, as described above.

The univariate models give some indication of the effect each risk factor has on the coverage level at age two years. The result of each risk factor in the multivariate models is adjusted for other factors in the model.

Statistical significance

Because the survey involves only a sample of the New Zealand population, any results presented for this population will have a margin of error. The 95% confidence interval is a range of numbers around the survey result that provides an indication of this margin of error. There is a 95% probability that the confidence interval will enclose the 'true' value for the New Zealand population. When the confidence interval of the coverage level within one group does not overlap the confidence interval of another group, it is possible to say that there is a statistically significant difference between the two groups.

The confidence interval is influenced by the sample size of the group. When there are more people in a group, the confidence interval is usually narrower; when there are fewer people in a group, the confidence interval is usually wider. In addition, when the sample size is small, the confidence interval becomes less reliable at estimating the margin of error. As a result, although it may appear that there is no statistical significance between two results, when the confidence intervals are wide it is not possible to say for certain there is no difference. In this report the use of the phrase 'significantly different' refers to a difference that is statistically significant. Overlapping confidence intervals, although not statistically significant, may still be demonstrating significant population group differences that require public health action, especially if the overlap is very small and the estimates for each group are very different.

Presentation of results

Results in this survey are presented with the population estimate first, followed by the 95% confidence interval. For example, the coverage level at age two years is presented in the following format: 77.4%; 75.3–79.5. The vertical line associated with each column on the column graphs also represents the 95% confidence interval.

Results

Demographics of survey respondents

This survey involved 1563 respondents. Table 2 shows the ethnic proportions of both the child and the caregiver respondent. Prioritised ethnicity was used for analysis.

Table 2: Ethnicity of survey respondents, by child and caregiver

	Child		Caregiver	
Ethnicity	**%**	**n**	**%**	**n**
Asian	7.9	123	7.6	118
Māori	28.1	439	22.5	352
European/Other:	52.7	824	58.9	921
European	52.1	814	58.2	909
Other	0.6	10	0.7	12
Pacific	11.3	177	11.0	172
Total	**100.0**	**1563**	**100.0**	**1563**

Because the age of the child and the date of the interview were not provided by the NRB it is not possible to present the range of ages. However using the date 31 January 2005 as a reference point to estimate the child's age, the average age was three years (2.96 years; 2.93–2.99) with no differences between ethnic groups or health regions. To be eligible for the survey, all children had to be two to three years old.

The demographic and personal characteristic data for the survey respondents, weighted to be representative of the New Zealand population, are shown in Table 3. The majority of caregivers (56.2%; 53.9–58.6) were in the age group 30–39 years old. Māori (48.8%; 43.4–54.1) and Pacific (40.6%; 33.8–47.5) caregivers had a significantly higher proportion of caregivers in the age group 20–29 years than European/Other caregivers (23.4%; 20.5–26.3). Over 90% (92.5%; 91.1–93.9) of caregiver respondents were the mother of the child. Few caregivers lived alone (9.1%; 7.6–10.5), although Māori caregivers were significantly more likely to be a caregiver living alone (19.7%; 14.9–24.6) compared with all other ethnic groups. Eighty-five percent of caregivers had either secondary (39.9%; 37.2–42.6) or tertiary qualifications (45.3%; 42.3–48.2). European/Other (48.5%; 45.0–52.1) and Asian (70.0%; 60.2–79.4) caregivers were significantly more likely to have a tertiary qualification than Māori (33.7%; 28.0–39.4) or Pacific caregivers (24.1%; 16.3–31.9).

Around 40% of all households were in the lowest income bracket ($40,000 or less). Pacific (71.3%; 62.7–80.0), Māori (59.0%; 53.6–64.5) and Asian (52.9%; 42.7–63.2) caregivers were significantly more likely than European/Other (28.9%; 25.7–32.2) caregivers to be living in a household earning $40,000 or less. One in five (20.2%; 18.0–22.6) survey households had more than five people living in the same household, and this was significantly more likely among respondents of Pacific ethnicity (49.4%; 41.3–57.6). Although nearly 40% (39.6%; 36.6–42.7) of children had not moved house since birth, a third (33.9%; 30.7–37.1) had moved on two or more occasions. Children of Māori caregivers were significantly more likely (45.7%; 38.8–52.6) to have moved on two or more occasions than children of European/Other (31.7%; 27.8–35.6) and Asian (24.5%; 16.3–32.7) caregivers. The difference was not significant when comparing children of Pacific and Māori caregivers.

The Well Child book was available from the survey respondents 73.3% (71.0–75.6) of the time. However, Māori (55.0%; 49.9–60.2) and Pacific (58.1%; 49.1–67.0) children were significantly less likely to have the book available compared with European/Other (82.2%; 79.1–85.4) and Asian children (80.7%; 73.4–87.9).

Table 3: Weighted demographic and personal characteristics of caregiver and household, by ethnicity (crude percentage)

Demographic/personal characteristic	Ethnicity				
	All	**Māori**	**Pacific**	**European/ Other**	**Asian**
Caregiver ethnicity		20.0 (18.8–21.2)	7.9 (7.3–8.5)	64.7 (62.8–66.6)	7.5 (5.9–9.1)
Caregiver age (by ethnicity of caregiver)					
< 20 years	0.9 (0.4–1.4)	3.1 (0.7–5.4)	0.0	0.3 (0.0–0.7)	1.0 (0.0–3.1)
20–29 years	30.0 (27.9–32.2)	48.8 43.4–54.1)	40.6 (33.8–47.5)	23.4 (20.5–26.3)	26.1 (17.4–34.8)
30–39 years	56.2 (53.9–58.6)	38.9 (33.5–44.2)	45.3 (37.6–53.1)	62.6 (59.4–65.9)	58.6 (49.2–67.9)
≥ 40 years	12.9 (11.1–14.6)	9.3 (5.7–13.0)	14.1 (8.6–19.6)	13.6 (11.5–15.8)	14.3 (7.5–21.1)
Caregiver relationship (by ethnicity of child)					
Father	5.9 (4.6–7.2)	4.8 (2.8–6.8)	6.3 (2.1–10.4)	6.1 (4.4–7.7)	7.8 (2.9–12.8)
Grandparent	0.9 (0.4–1.5)	2.1 (0.5–3.6)	2.6 (0.0–5.3)	0.2 (0.0–0.5)	1.2 (0.0–3.5)
Mother	92.5 (91.1–93.9)	91.7 (88.7–94.7)	90.1 (85.3–94.9)	93.5 (91.8–95.2)	89.8 (84.0–95.5)
Other	0.7 (0.3–1.1)	1.5 (0.3–2.6)	1.0 (0.0–2.4)	0.3 (0.0–0.6)	1.3 (0.0–3.2)

Demographic/personal characteristic	Ethnicity				
	All	Māori	Pacific	European/ Other	Asian
Caregiver living status (by ethnicity of caregiver)					
Living alone	9.1 (7.6–10.5)	19.7 (14.9–24.6)	4.8 (1.5–8.0)	7.4 (5.7–9.0)	0.0
Living with others	10.0 (8.4–11.6)	20.3 (15.1–25.6)	17.7 (12.1–23.3)	6.1 (4.4–7.7)	8.0 (2.3–13.7)
Living with partner	80.9 (78.9–82.9)	59.5 (54.1–64.9)	77.6 (71.5–83.7)	86.6 (84.4–88.8)	92.1 (86.4–97.8)
Refused/other	0.1 (0.0–0.3)	0.5 (0.0–1.4)	0.0	0.0	0.0
Caregiver qualification (by ethnicity of caregiver)					
No qualification	14.8 (13.0–16.7)	27.3 (21.7–32.9)	28.7 (20.6–36.7)	10.4 (8.2–12.7)	5.8 (1.6–10.0)
Secondary qualification	39.9 (37.2–42.6)	39.0 (33.6–44.5)	47.3 (37.9–56.7)	41.1 (37.7–44.4)	24.2 (15.4–32.9)
Tertiary qualification	45.3 (42.3–48.2)	33.7 (28.0–39.4)	24.1 (16.3–31.9)	48.5 (45.0–52.1)	70.0 (60.2–79.9)
Household income (by ethnicity of caregiver)					
≤ $40,000	39.4 (36.5–42.2)	59.0 (53.6–64.5)	71.3 (62.7–80.0	28.9 (25.7–32.2)	52.9 (42.7–63.2)
$40,001–$70,000	34.8 (31.9–37.7)	28.5 (22.8–34.1)	20.4 (12.5–28.3)	39.4 (35.6–43.3)	21.7 (14.2–29.3)
≥ $70,001	25.9 (22.8–29.0)	12.5 (8.3–16.7)	8.3 (3.2–13.3)	31.7 (27.5–35.8)	25.3 (15.5–35.2)
Number of people in household (by ethnicity of child)					
≤ 5 people	79.8 (77.4–82.1)	69.2 (64.1–74.4)	50.6 (42.4–58.7)	88.8 (86.3–91.2)	77.4 (67.8–87.0)
> 5 people	20.3 (18.0–22.6)	30.8 (25.7–35.9)	49.4 (41.3–57.6)	11.3 (8.8–13.7)	22.6 (13.0–32.2)
Number of moves since birth of child (by ethnicity of caregiver)					
Never	39.6 (36.6–42.7)	31.6 (25.5–37.7)	43.1 (36.3–49.9)	42.2 (38.6–45.9)	34.6 (24.5–44.8)
Once	26.5 (24.0–29.0)	22.7 (17.9–27.5)	25.9 (18.3–33.6)	26.0 (22.7–29.4)	40.9 (29.9–51.9)
≥ 2 times	33.9 (30.7–37.1)	45.7 (38.8–52.6)	31.0 (22.7–39.2)	31.7 (27.8–35.6)	24.5 (16.3–32.7)
Availability of Well Child book (by ethnicity of child)	73.3 (71.0–75.6)	55.0 (49.9–60.2)	58.1 (49.1–67.0)	82.2 (79.1–85.4)	80.7 (73.4–87.9)

Coverage

This report provides different measures of immunisation coverage levels: at age one year, age two years, at the time of the survey (includes ages two to under four years), and on-time immunisation (within four weeks of the due date according to the National Immunisation Schedule and on time according to the correct interval between sequential doses). The term coverage is used to mean the proportion of children who have either been immunised with a specific vaccine or who have completed an immunisation series (Ministry of Health 2002). Immunisation coverage levels at age two years are useful to compare with international coverage levels, and to assess changes over time and comparisons between different areas and population groups. However, it is important to know coverage levels at age one year and at 15–16 months of age when looking at the performance of an immunisation programme. Table 4 shows the immunisation schedule the survey analysis was based on.

The most conservative estimates of coverage are presented in this report, because only those children with written documentation of having received a vaccination were accepted as being vaccinated. However, there was little increase in coverage levels when including caregiver recall as well as documented evidence: the proportion of children fully immunised at the time of the survey increased from 82.7% (80.7–84.6) to 83.0% (81.0–85.0).

Although the survey was not designed to provide coverage levels at the DHB level, analysis was done at this level, providing an indication of relative coverage levels between DHBs.

Table 4: Immunisation schedule for analysis of coverage (2001/02)

Dose number	Vaccine and age of child when vaccine delivered					
	DTaP (DTP)	**IPV or OPV**	**Hib**	**Hep B**	**MMR**	**BCG**
Neonatal				If mother carrier (including HBIG)		At birth for certain risk groups
1	6 weeks	6 weeks	6 weeks	6 weeks	15 months	
2	3 months	3 months	3 months	3 months		
3	5 months	5 months	15 months	5 months		
4	15 months					

Notes: DTaP = diphtheria, tetanus and acellular pertussis vaccine; DTP = diphtheria, tetanus and pertussis vaccine; IPV = inactivated polio vaccine; OPV = oral polio vaccine; Hib = *Haemophilus influenzae* type b vaccine; Hep B = hepatitis B vaccine; MMR = measles, mumps and rubella vaccine; BCG = bacillus Calmette-Guérin vaccine; HBIG = hepatitis B immunoglobulin.

Fully immunised at age one year includes:

- three doses of diphtheria, tetanus and acellular pertussis vaccine (DTaP)
- three doses of polio vaccine (IPV or OPV)
- two doses of *Haemophilus influenzae* type b vaccine (Hib)

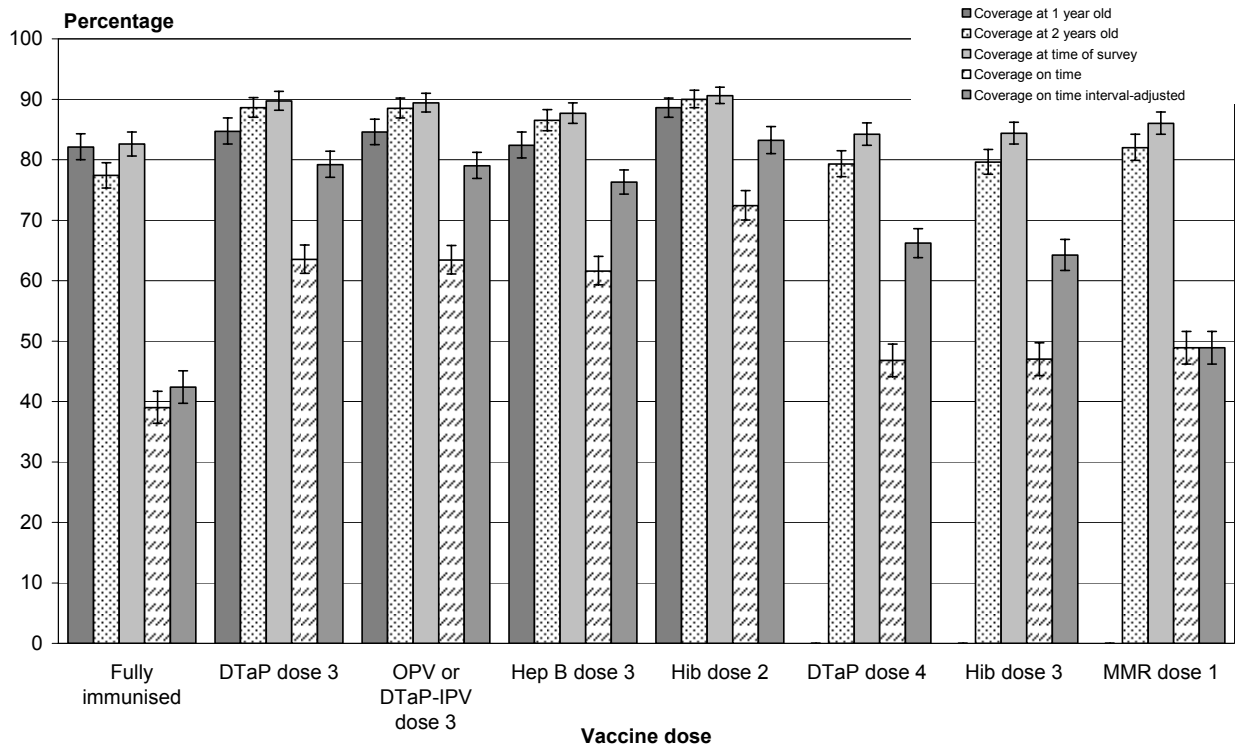
- three doses of hepatitis B vaccine (or four doses including the neonatal dose of hepatitis B vaccine and immunoglobulin if required).

Fully immunised at age two years includes:

- four doses of diphtheria, tetanus and acellular pertussis vaccine (DTaP)
- three doses of polio vaccine (IPV or OPV)
- three doses of *Haemophilus influenzae* type b vaccine (Hib)
- three doses of hepatitis B vaccine (or four doses including neonatal doses if required)
- one dose of measles, mumps and rubella vaccine (MMR)

Fully immunised status does not include bacillus Calmette-Guérin (BCG) vaccination.

Figure 1: Fully immunised and final dose vaccine coverage, comparison of different end points (percentage)

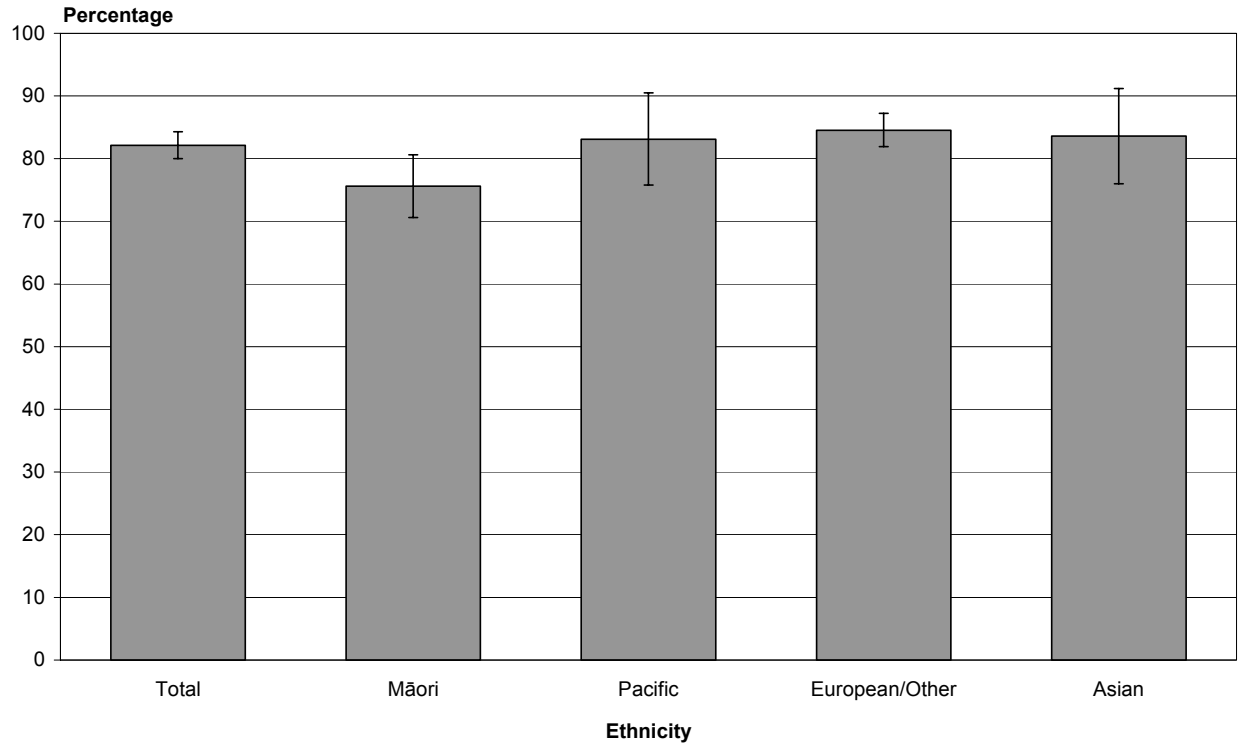


Notes: DTaP = diphtheria, tetanus and acellular pertussis vaccine; IPV = inactivated polio vaccine; OPV = oral polio vaccine; Hep B = hepatitis B vaccine; Hib = *Haemophilus influenzae* type b vaccine; MMR = measles, mumps and rubella vaccine. The numerator for 'fully immunised at one year' included two children that had no record of receiving neonatal HBIG when the mother was identified as being a carrier of hepatitis B. They did, however, go on to receive all three subsequent doses of Hep B vaccine.

Coverage levels at age one year

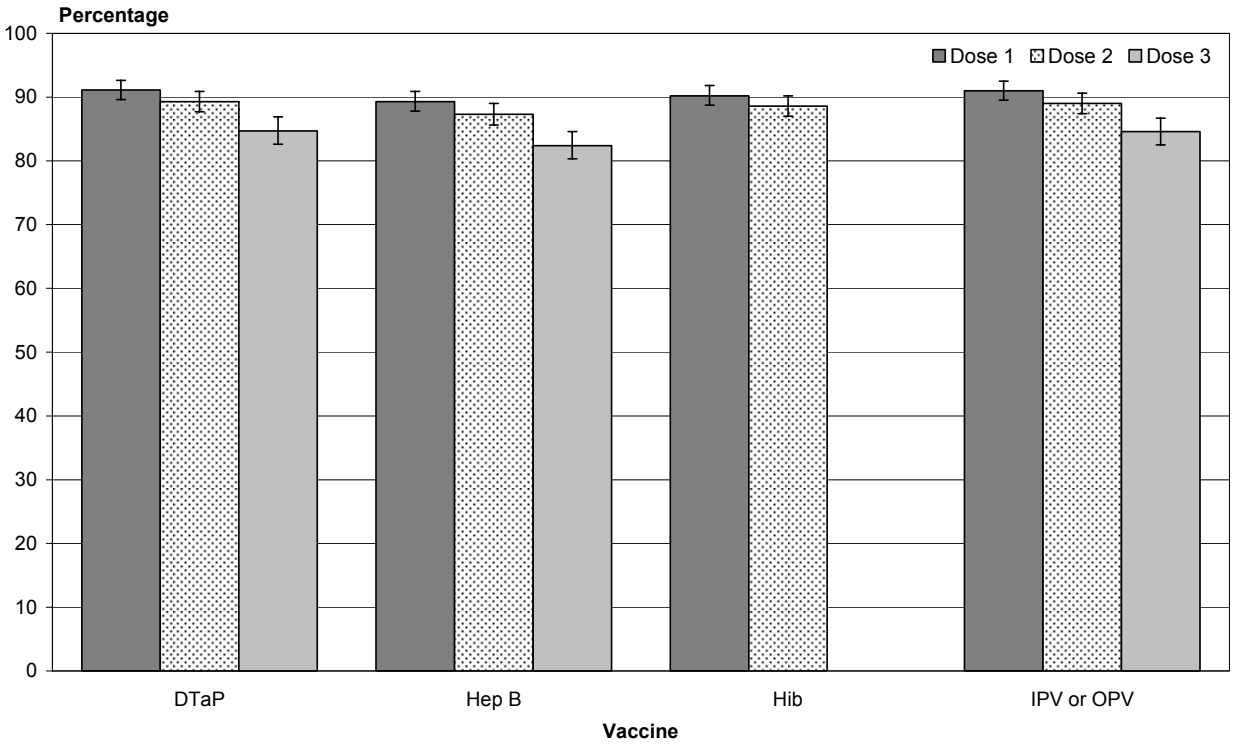
At age one year the fully immunised coverage level for childhood vaccination was 82.1% (80.0–84.3) (Figure 1). Māori children (75.6%; 70.6–80.6) were significantly less likely to be fully immunised than European/Other children (84.5%; 81.9–87.2) (Figure 2). No DHB was significantly lower than the New Zealand coverage level (Appendix 3, Table A3-3).

Figure 2: Fully immunised coverage at age one year, by ethnicity of child (percentage)



The five-month vaccines (DTaP 3, Polio 3, and Hep B 3) were significantly less likely to be given than the three-month vaccines (DTaP 2, Polio 2, Hib 2, Hep B 2) (Figure 3). For the individual vaccine doses DTaP 3, Polio 2 and 3, Hib 2, and Hep B 3, Māori children were significantly less likely to be immunised than European/Other children (Appendix 3, Table A3-4). For vaccine doses DTaP 1 and 2, and polio 1, Māori children were significantly less likely to be immunised than Pacific children (Appendix 3, Table A3-4).

Figure 3: Individual vaccine coverage at age one year, by vaccine dose (percentage)

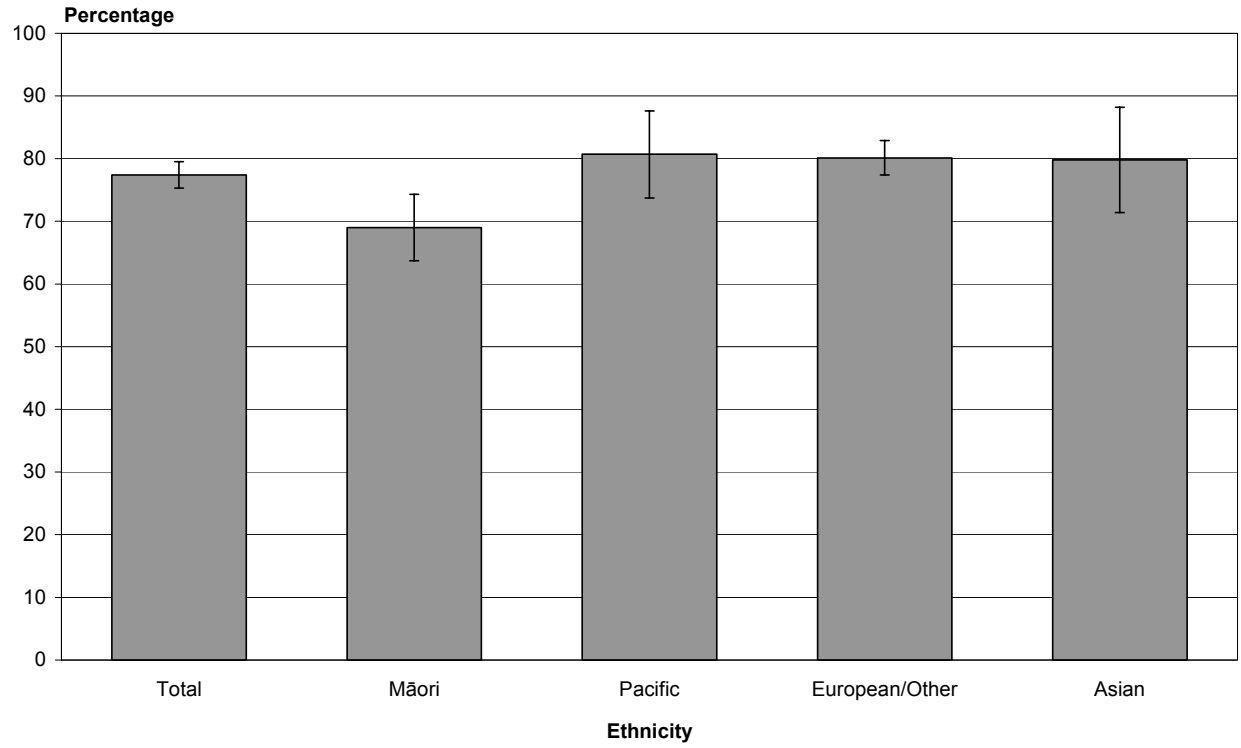


Notes: DTaP = diphtheria, tetanus and acellular pertussis vaccine; Hep B = hepatitis B vaccine; Hib = *Haemophilus influenzae* type b vaccine; IPV = inactivated polio vaccine; OPV = oral polio vaccine.

Coverage levels at age two years

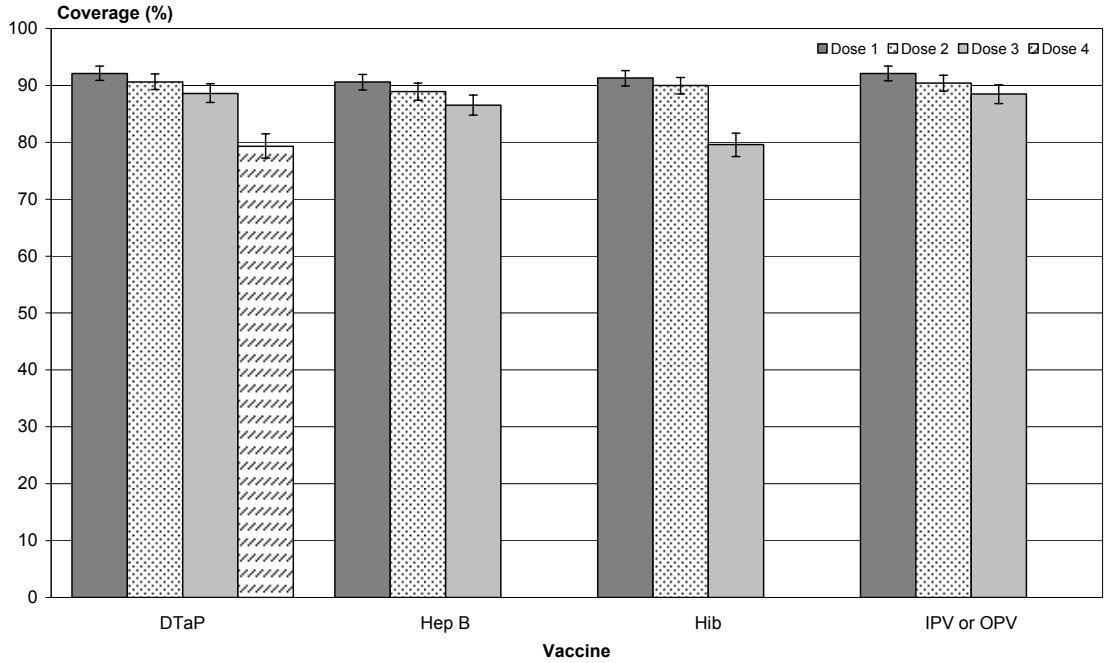
The coverage level for fully immunised at age two years (77.4%; 75.3–79.5) was significantly lower than at age one year (82.1%; 80.0–84.3) (Figure 1). Māori children were significantly less likely to be fully immunised (69.0%; 63.7–74.3) than European/ Other children (80.1%; 77.4–82.9) (Figure 4). Pacific children had the highest coverage level at 80.7% (73.7–87.6), but this was not statistically significantly different from any other ethnic group.

Figure 4: Fully immunised coverage at age two years, by ethnicity of child (percentage)



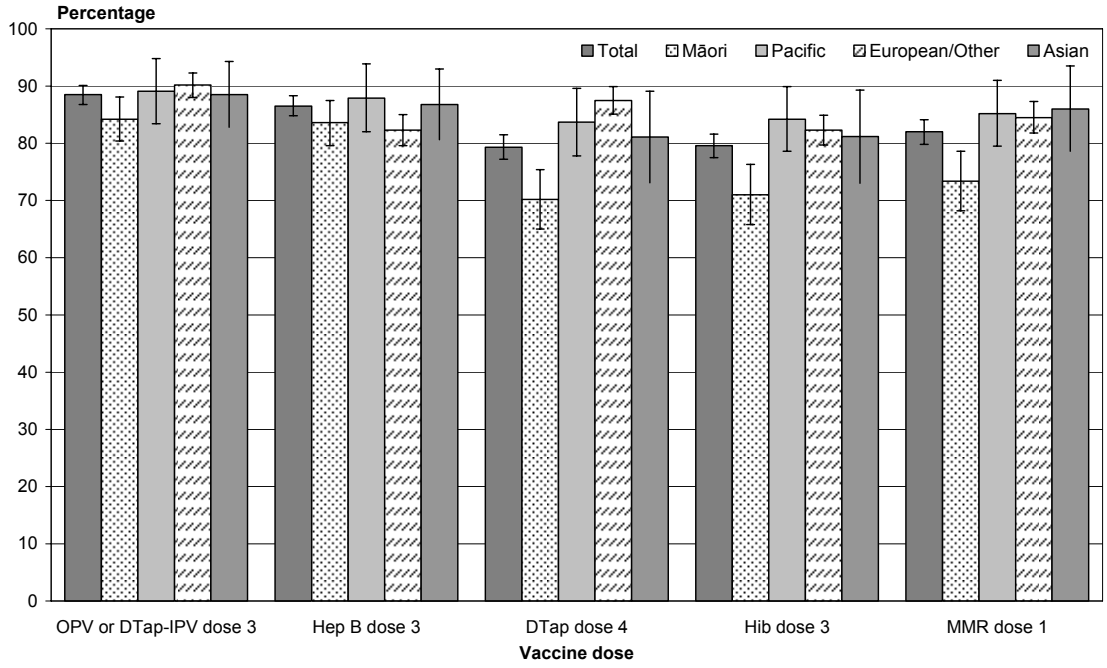
The trend is for decreasing coverage for each successive dose of an individual vaccine (Figure 5). However, the greatest decrease, and the only significant sequential dose decline, was for the 15-month dose of DTaP 4 and Hib 3. Coverage levels for the final doses of individual vaccines for this age group were lower for Māori children compared with other ethnic groups (Figure 6), but the differences were only significant for the 15-month vaccines (ie DTaP, Hib, MMR). Māori children had significantly lower coverage than European/Other and Pacific children.

Figure 5: Individual vaccine coverage at age two years, by vaccine dose (percentage)



Notes: DTaP = diphtheria, tetanus and acellular pertussis vaccine; Hep B = hepatitis B vaccine; Hib = *Haemophilus influenzae* type b vaccine; IPV = inactivated polio vaccine; OPV = oral polio vaccine.

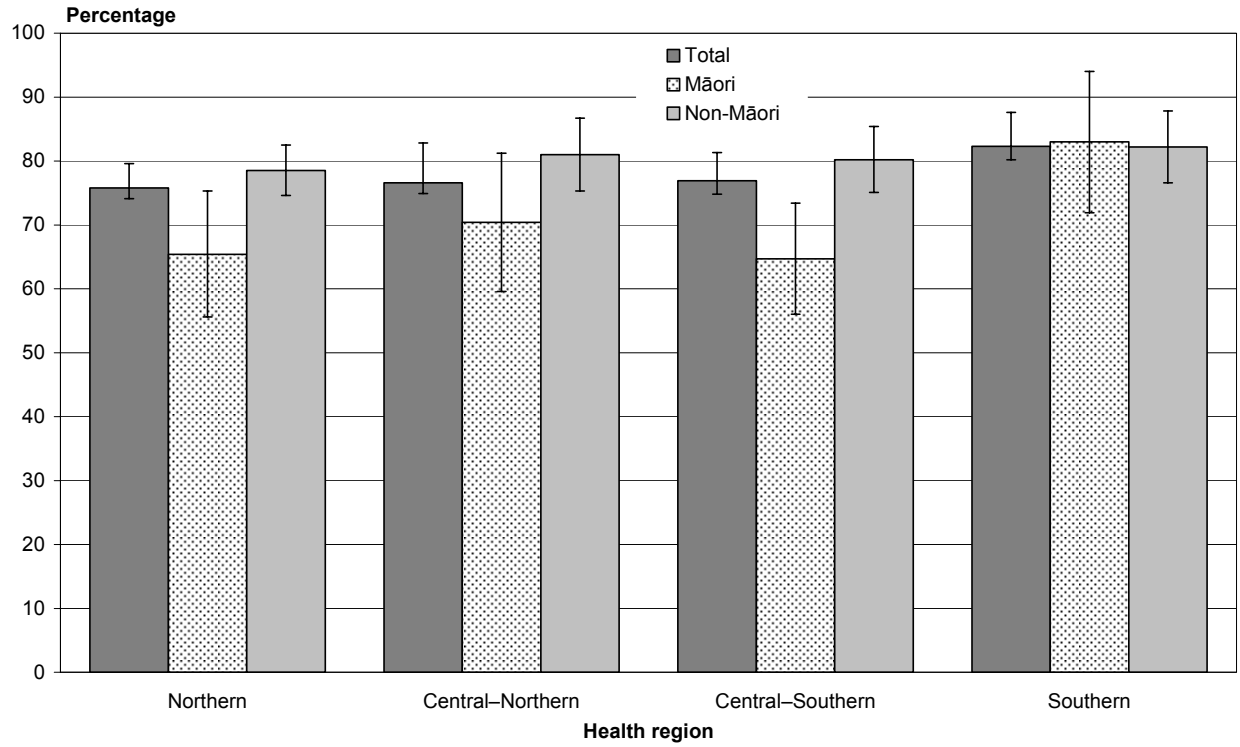
Figure 6: Final dose coverage of individual vaccines at age two years, by ethnicity of child (percentage)



Notes: DTaP = diphtheria, tetanus and acellular pertussis vaccine; IPV = inactivated polio vaccine; OPV = oral polio vaccine; Hep B = hepatitis B vaccine; Hib = *Haemophilus influenzae* type b vaccine; MMR = measles, mumps and rubella vaccine. Although DTaP 4 and Hib 3 are usually given as a combined vaccine, there was some variation in the figures for the separate components, in that being up to date with this vaccine required documentation of having received all other previous doses of both DTaP and Hib. Therefore the figures are presented separately.

When coverage data were aggregated into the four health regions there were no significant differences in fully immunised coverage levels between the regions, although there was a north–south trend of improving coverage (Figure 7).

Figure 7: Fully immunised coverage at age two years, by health region and ethnicity of child (percentage)



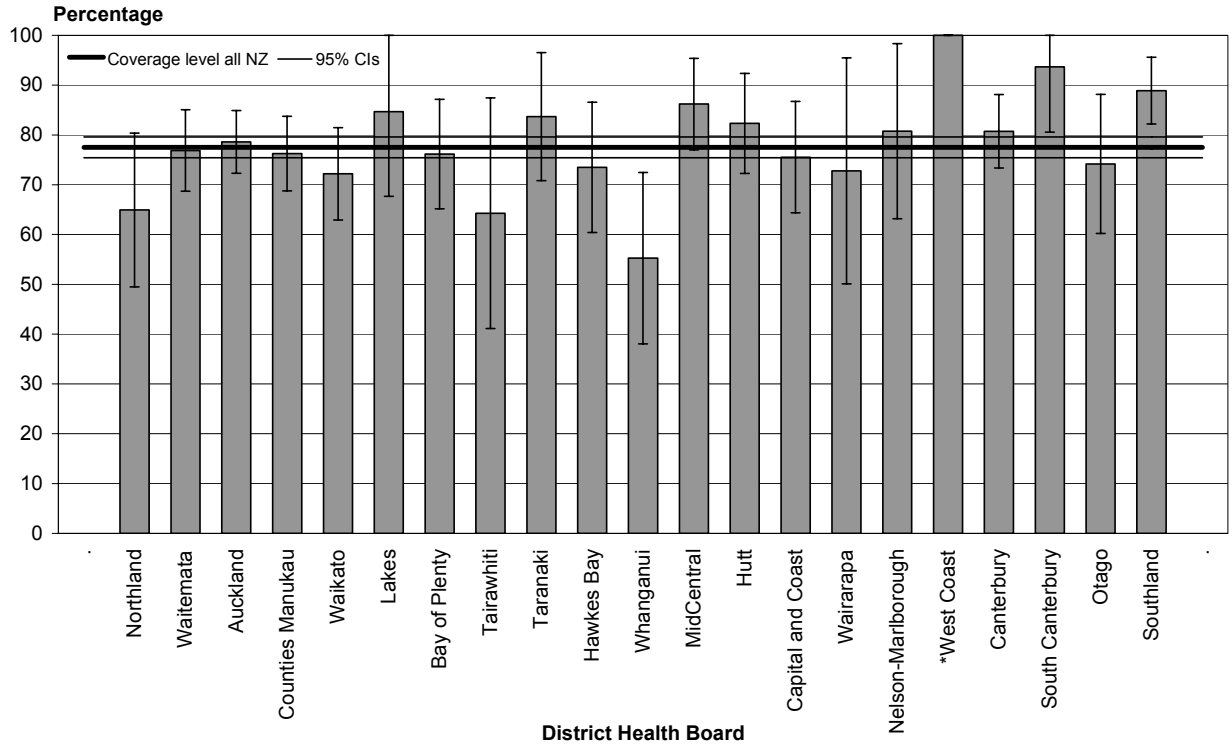
The Southern health region had the best coverage for Māori children compared with non-Māori children (Figure 7).[9] The Central–Southern health region coverage level for Māori children (64.7%; 56.0–73.4) was significantly lower than the non-Māori children coverage levels (80.2%; 75.1–85.4).

South Canterbury and Southland DHBs had significantly higher coverage than the New Zealand coverage level,[10] while Whanganui DHB had significantly lower coverage than the New Zealand coverage level (Figure 8). Final dose coverage levels by DHB are shown in Appendix 3 (Table A3-6). However, caution should be used when comparing DHBs' coverage levels as small numbers are involved in analyses.

[9] This may not indicate that the DHBs in this region were more successful at immunising Māori children, and may merely reflect the underlying population structure, as the Southern region has the lowest proportion of Māori children and Central–Northern has the highest proportion of Māori children.

[10] The West Coast DHB also had a coverage level higher than the New Zealand coverage level. However, the count was less than 10 for this DHB and therefore the result is not included as being significant given the statistical uncertainty associated with such a small number.

Figure 8: Fully immunised coverage at age two years, by District Health Board (percentage)

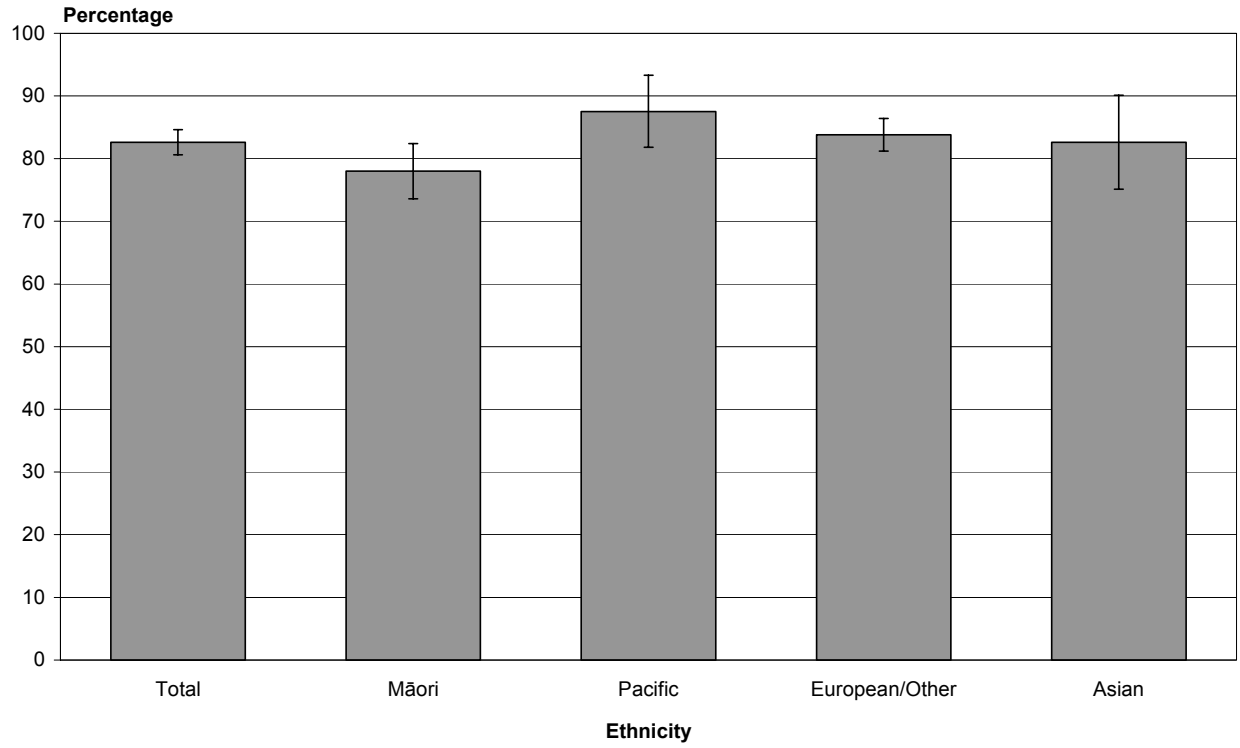


Note: *Count <10.

Coverage levels at the time of the survey

When looking at fully immunised coverage at the time of the survey, the coverage level refers to a range of ages (two to three years). As a result, there was more opportunity for some children to have received catch-up vaccines if they were closer to four years old at the time of the survey. The fully immunised coverage level at the time of the survey was significantly higher (82.6%; 80.6–84.6) than coverage at age two years (77.4; 75.3–79.5) (Figure 1). Although there were no statistical differences in coverage levels at the time of the survey between ethnic groups, Māori children had the lowest coverage level at 78.0% (73.6–82.4) and Pacific children the highest at 87.5% (81.8–93.3) (Figure 9). The comparison of coverage levels at the time of the survey between different DHBs is shown in Appendix 3 (Table A3-3).

Figure 9: Fully immunised coverage at time of the survey, by ethnicity of child (percentage)



Coverage levels on time

To determine if vaccination was given on time, the time period in days between the date of vaccination and a child's date of birth was compared to the age (in days) the immunisation schedule recommends delivery of the vaccine. A vaccine was determined to be 'on time' when the calculated age a child received a vaccine was within 30 days of the recommended age of vaccination (Table 5).

One problem with using this definition for on-time vaccination occurs when calculating a coverage level for those fully vaccinated. This is because if an initial vaccine is given late, then most of the subsequent vaccines are also likely to be late to allow for the correct time intervals between vaccine doses. A solution to this is to calculate the interval between sequential vaccines and compare this with the recommended interval between sequential doses from the immunisation schedule. An interval-adjusted on-time dose required the vaccine to be given within 30 days of the recommended interval between sequential vaccine doses (Table 5).

Table 5: Definitions of on-time and on-time interval-adjusted vaccinations (days)

On-time vaccination upper limits (days)					
Dose	**DTaP**	**IPV or OPV**	**Hib**	**Heb B**	**MMR**
1	75	75	75	75	480
2	120	120	120	120	
3	180	180	480	180	
4	480				
On-time interval-adjusted vaccination upper limits (days)					
Dose	**DTaP**	**IPV or OPV**	**Hib**	**Heb B**	**MMR**
1	75	75	75	75	480
2	75	75	75	75	
3	90	90	390	90	
4	330				

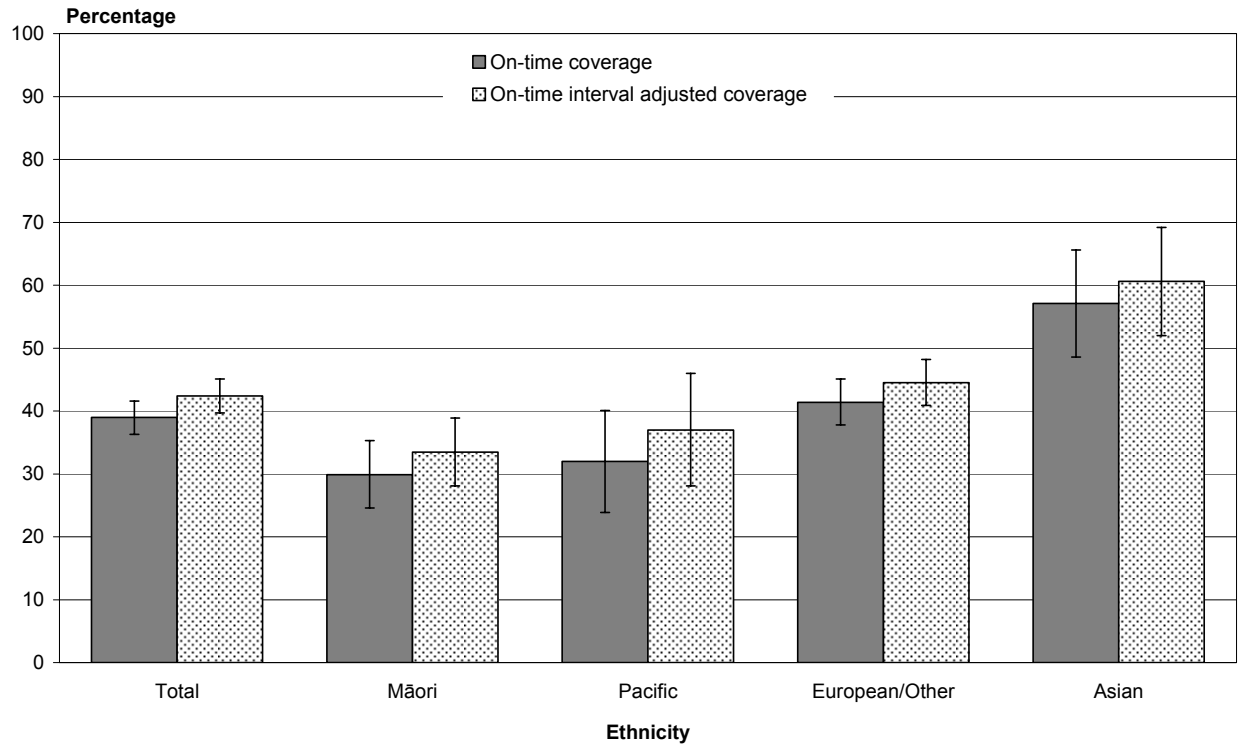
Notes: DTaP = diphtheria, tetanus and acellular pertussis vaccine; IPV = inactivated polio vaccine; OPV = oral polio vaccine, Hep B = hepatitis B vaccine; Hib = *Haemophilus influenzae* type b vaccine; MMR = measles, mumps and rubella vaccine.

Coverage levels based on both the age at vaccination and the interval between vaccinations are presented here. Results based on the interval between vaccines required a correction to be made if the preceding dose was given to a child earlier than the recommended scheduled age. Thus, intervals were calculated from the date a child was recorded as being given a vaccine, if not given earlier than recommended, otherwise the interval was calculated using the recommended age of delivery for the preceding dose.

As we have seen, Figure 1 compares coverage levels for estimated on-time delivery by recommended age of vaccination and on-time delivery focused on the interval between sequential doses, along with the other end points assessed for coverage levels. The delivery of vaccinations on time, as defined by the recommended schedule, is significantly lower than all other coverage levels measured for fully immunised status and for all final-dose vaccinations (Figure 1). Adjusting final doses for the interval between sequential doses significantly improves the individual vaccine coverage levels compared with unadjusted on-time coverage levels (Figure 1). However, the fully immunised on-time interval-adjusted coverage level (42.4%; 39.7–45.1) was not significantly higher than the on-time unadjusted coverage level (39.0%; 36.3–41.6).

Figure 10 shows the on-time vaccination coverage levels by ethnicity. Asian children are significantly more likely (57.1%; 48.6–65.6 interval unadjusted and 60.6%; 52.0–69.2 interval adjusted) to receive vaccinations on time than any other ethnicity. Māori children were significantly less likely (29.9%; 24.6–35.3 interval unadjusted and 33.5%; 28.1–38.9 interval adjusted) to be vaccinated on time compared with Asian and European/Other children.

Figure 10: On-time and on-time interval-adjusted fully immunised coverage, by ethnicity of child (percentage)



There were no significant differences between on-time coverage levels by health region, although the trend was for the Southern region to achieve better coverage than the Northern and Central regions (Appendix 3, Table A3-2).

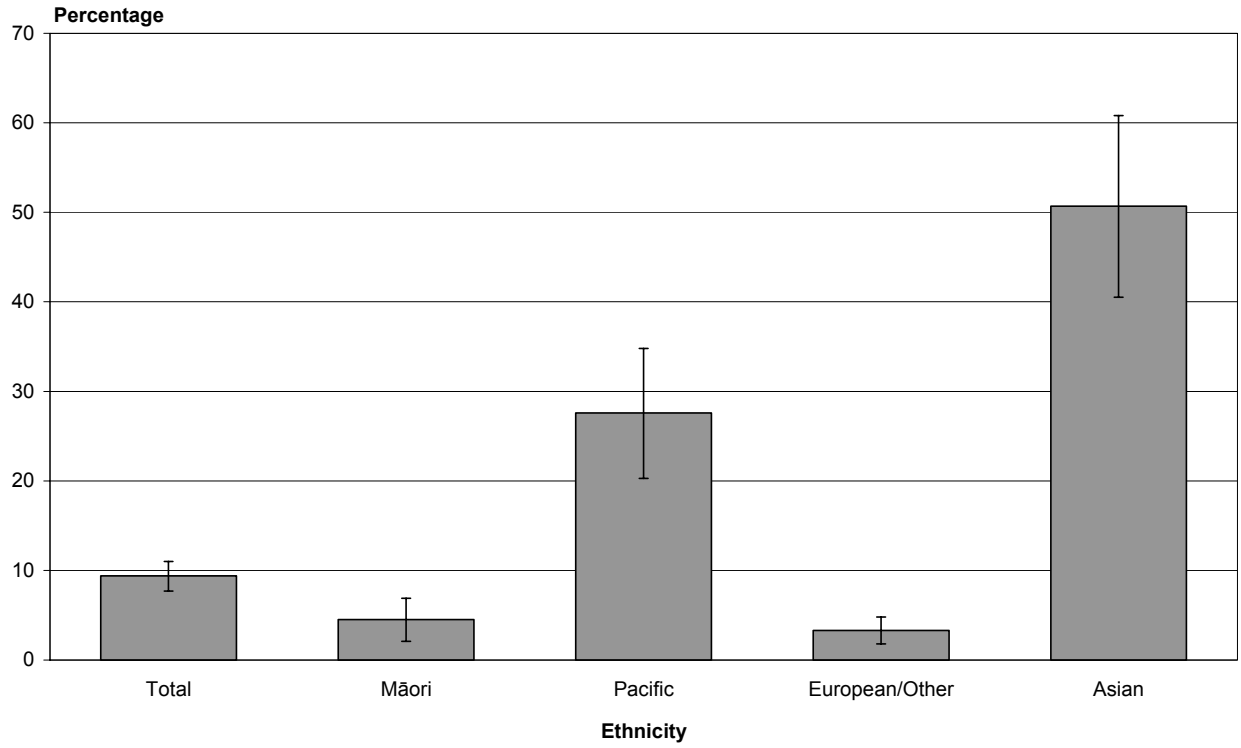
Hepatitis B immunoprophylaxis in infants born to hepatitis B positive mothers

The prevalence of mothers who are carriers of hepatitis B was 2.0% (n=31) in this survey. A New Zealand study in 1984 estimated the prevalence of hepatitis B in pregnant women to be 3.3% (Miller and Hermon 1984). For babies born to hepatitis B carriers, it is recommended that hepatitis B immunoglobulin be given as soon as possible after birth, and preferably within 12 hours, although it can be given up to seven days after birth. The total coverage for immunoglobulin administration was 72.0% (53.5–90.5). A cut-off of 48 hours was used in the survey analysis to determine if the immunoglobulin was given on time. Sixty-three percent of children had immunoglobulin given on time, 23% had it given late, and 13% had no record of administration and so it was categorised as not given.

Bacillus Calmette-Guérin vaccination coverage

In this survey 9.4% (7.7–11.0) of children were documented as having received a BCG vaccination. These were significantly more likely to be Asian children (50.7%; 40.5–60.8), followed by Pacific children (27.6%; 20.3–34.8) (Figure 11). There was no significant difference between Māori and European/Other children.

Figure 11: BCG vaccination coverage, by ethnicity of child (percentage)



The coverage level was significantly higher for the Northern health region (17.8%; 14.3–21.3) compared with the other three regions (data not shown). Auckland, Counties Manukau and Capital and Coast DHBs had over 15% of the two- and three-year-old population vaccinated with BCG. Auckland babies had statistically higher BCG coverage (26.7%, 19.2–34.2) than in many of the DHBs, although many of the DHBs had small numbers of children receiving BCG vaccination (data not shown).

Reasons for missed immunisations

At the time of the survey 17.2% (n=269) children surveyed had missed one or more vaccinations, and 93% (n= 250) of the caregivers surveyed provided the main reason for the missed vaccination(s). The full results of this analysis using population estimates are presented in Appendix 3 (Table A3-7). Most of the analysis involved very small numbers, and so the discussion of results is limited to the top four reasons for missed immunisations, and results with counts of 10 or more represent more robust data to explore reasons for missed immunisations.

The top four most frequently identified reasons for missed immunisations were: concern about the risk associated with vaccination (25.2%; 19.4–31.0); use of a different immunisation schedule or vaccination undertaken overseas (19.1%; 13.4–24.7); a medical reason (although this did not distinguish between minor illness and a significant medical contraindication) (11.0%; 6.8–15.2); and belief that their child had been vaccinated but the records could not confirm this (8.1%; 4.7–11.6). The latter reason was significantly less frequently given than the top two reasons.

Table 6 looks at the four highest-frequency reasons for missed vaccinations for each caregiver ethnicity. For Māori caregivers the top reasons included the risk associated with immunisation, the child was believed to have been vaccinated but there were no records to prove this, and medical reasons. For European/Other caregivers the risk associated with immunisation, different schedule/immunisation done overseas, medical reasons, and concern about a particular vaccine were the top four reasons for missed vaccinations. Missed vaccinations for children of Asian caregivers were most commonly due to use of an overseas immunisation schedule (57.9%; 34.5–81.4) than any other reason. The number of Pacific respondents in this survey was too low to provide robust data on reasons for missed immunisations.

Table 6: Top four reasons for missed immunisations, for each caregiver ethnicity (percentage)

	Ethnicity							
	Māori		**Pacific**		**European/Other**		**Asian**	
Reason	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**
Risk associated with immunisation	23.9 (11.6–36.2)	13			29.2 (21.3–37.2)	44	6.6 (0.0–20.0)	1
Different schedule/ immunisation done overseas					22.4 (14.7–30.2)	31	57.9 (34.0–81.4)	10
Medical reasons	12.3 (3.8–20.9)	10	14.4 (0.0–35.1)	2	9.9 (4.5–15.4)	14	13.7 (0.0–32.5)	2
Child believed to be vaccinated but records do not show it done	14.0 (5.7–22.3)	12	13.1 (0.0–33.3)	2			12.3 (0.0–29.5)	2
Concern about a particular vaccine					8.1 (3.3–12.9)	13		
Forgot to get it done	7.3 (0.0–14.9)	4						
No reason given			12.0 (0.0–36.6)	2				
Too busy			23.5 (0.0–50.3)	3				

Note: Shaded areas indicate results based on counts < 10. These results should be treated with caution.

Analysis of the reasons for missed immunisations by the four health regions is shown in Table 7. All regions had the reasons risk associated with immunisation and different overseas schedules as the top two reasons, and all but the Northern region cited medical reasons as the third most common reason for missed vaccinations. However, the only statistically significant result was from the Central–Northern region, where the risk associated with immunisation (38.3%; 22.0–54.6) was significantly more likely to be the explanation given for incomplete vaccination than other reasons.

Table 7: Top four reasons for missed immunisations, for each health region (percentage)

Reason	Health region							
	Northern		Central–Northern		Central–Southern		Southern	
	%	n	%	n	%	n	%	n
Child believed to be vaccinated but records do not show it done	12.9 (5.3–20.5)	13					9.2 (0.0–21.3)	3
Concern about a particular vaccine					7.0 (0.2–13.7)	4		
Different schedule/ immunisation done overseas	18.6 (8.6–28.6)	15	10.7 (0.6–20.7)	6	22.5 (9.6–35.4)	12	27.9 (12.1–43.6)	10
Forgot to get it done			7.6 (0.0–16.0)	4				
Medical reasons	6.0 (0.5–11.4)	6	9.7 (0.9–18.4)	5	17.3 (7.2–27.4)	12	14.5 (1.7–27.3)	5
Risk associated with immunisation	19.0 (11.1–26.9)	18	38.3 (22.0–54.6)	19	23.6 (12.1–35.0)	14	22.0 (8.3–35.7)	8

Note: Shaded areas indicate results based on counts < 10. These results should be treated with caution.

Caregiver knowledge and attitudes to vaccine-preventable diseases and immunisation

This survey attempted to explore some of the caregivers' underlying attitudes towards and understanding of childhood vaccination. The full results are presented in Appendix 3, Table A3-8. Table 8 summarises the main viewpoints of caregivers regarding statements presented in the survey.

Table 8: Summary of caregiver attitudes and understanding of childhood immunisation

> 80% respondents agree that:	> 80% respondents disagree that:
All childhood immunisations are important	There is no need for immunisation if the child is healthy
Diseases like these can be serious for young children	Unnecessary to have many injections since diseases protected against have died out
Unless vaccinated my child could catch diseases	Only people in certain areas need to have children immunised
Vaccines are effective in stopping children from catching diseases	Only one injection is needed and the follow-up boosters can be skipped
Immunisation is free for all children	
Parents/caregivers have a responsibility to ensure children are immunised	
Doctors or nurses seem to be firmly in favour of immunisation	

A reminder when immunisations are due would be useful	

There were also some responses of concern in less than 80% of respondents, which may contribute to under-immunisation and should provide a prompt to action (Table 9). Over 50% (52.4%; 49.6–55.3) of caregivers believed that immunisations can cause serious side-effects, although nearly 80% (76.7%; 74.4–78.9) of caregivers believed that serious side-effects from immunisations are rare (Table 9). Caregivers of European/Other children were significantly more likely to agree with the statement that immunisation can cause serious side-effects (59.0%; 55.2–62.8) than caregivers of children of other ethnicities. However, caregivers of European/Other children were also significantly more likely to agree that serious side-effects from immunisation are a rare event (84.3%; 81.6–87.0), compared with caregivers of Māori (65.1%; 60.6–69.6) or Pacific (58.9%; 50.5–67.3) children (Table 9).

Approximately 30% (29.1; 26.1–32.0) of caregivers believed that immunisations are too upsetting or painful for young children (Table 9). Caregivers of Māori, Pacific and Asian children were more likely to agree with this than caregivers of European/Other children. Nearly 60% (58.7%; 55.7–61.6) of caregivers believed that the child should not be taken for immunisation if they have any illness, even a mild cold. Caregivers of European/Other children were significantly more likely to agree with this (63.3%; 59.4–67.2) than caregivers of Pacific (44.9%; 35.0–54.9) or Asian (45.7%; 37.6–53.8) children.

Table 9: Caregiver's agreement with statements about immunisation, by ethnicity of child (percentage)

	Ethnicity				
Statement	**All**	**Māori**	**Pacific**	**European/ Other**	**Asian**
All childhood immunisations are important	89.1 (87.3–90.8)	91.2 (88.1–94.3)	97.1 (93.3–100.0)	87.0 (84.5–89.5)	89.5 (84.0–95.0)
Doctors/nurses should provide more information on the benefits/risks of immunisation	64.2 (61.3–67.1)	72.0 (67.5–76.4)	87.4 (82.3–92.5)	54.8 (50.7–58.8)	85.3 (77.9–92.6)
Hard to remember when children are due for immunisations	33.7 (31.6–35.8)	42.7 (37.7–47.8)	44.4 (35.4–53.5)	26.3 (23.2–29.3)	49.4 (40.8–58.0)
Immunisation injections are too upsetting/painful for young children	29.1 (26.1–32.0)	40.1 (34.6–45.7)	52.2 (42.7–61.7)	19.4 (15.9–22.9)	41.5 (31.6–51.5)
Immunisation records should be checked at school entry so vaccination can be given to those who missed out	75.1 (73.0–77.2)	77.3 (72.7–81.9)	94.8 (90.5–99.0)	69.4 (66.5–72.4)	89.1 (83.5–94.8)

Statement	Ethnicity				
	All	Māori	Pacific	European/ Other	Asian
Immunisations should be required by all children before they enter school	62.7 (60.0–65.4)	66.0 (61.0–70.9)	82.3 (76.2–88.4)	55.4 (51.8–59.0)	85.9 (80.1–91.7)
Immunisations can cause serious side-effects	52.4 (49.6–55.3)	48.4 (43.3–53.4)	35.4 (26.9–43.9)	59.0 (55.2–62.8)	34.3 (26.0–42.7)
Serious side-effects from immunisations are rare	76.7 (74.4–78.9)	65.1 (60.6–69.6)	58.9 (50.5–67.3)	84.3 (81.6–87.0)	75.4 (66.9–83.9)
Mild case of disease builds up better protection	16.9 (14.6–19.1)	12.9 (8.9–16.8)	31.6 (22.9–40.2)	14.6 (11.7–17.5)	30.4 (20.3–40.6)
Unnecessary to have many injections since the diseases protected against have died out	7.7 (6.3–9.1)	8.0 (4.9–11.2)	18.4 (11.3–25.4)	5.3 (3.8–6.8)	13.0 (6.3–19.7)
Only people in certain areas need to have children immunised	3.9 (2.7–5.1)	3.3 (0.7–5.8)	10.9 (5.1–16.6)	2.7 (1.6–3.9)	7.1 (1.4–12.7)
Should not take child for immunisation if has an illness/mild cold	58.7 (55.7–61.6)	56.4 (51.4–61.4)	45.7 (37.6–53.8)	63.3 (59.4–67.2)	44.9 (35.0–54.9)
Travelling and waiting time at doctors makes it difficult to have child immunised	19.0 (16.6–21.4)	27.7 (22.6–32.7)	30.7 (23.1–38.3)	12.4 (9.8–15.0)	28.3 (19.5–37.2)
Would rather have nurse come to house to give child immunisations than go to doctor's surgery	33.7 (31.0-36.4)	44.4 (38.5–50.2)	46.0 (37.3–54.8)	26.2 (23.0–29.4)	42.8 (33.4–52.2)
Would rather my child be immunised at same time as a visit to their child health nurse	42.7 (40.0–45.4)	49.9 (44.3–55.5)	61.7 (53.1–70.3)	35.4 (32.1–38.7)	54.4 (45.2–63.6)
Caregivers with English as a second language Would understand more about immunisations if information was in my own language	62.5 (54.5–70.4)	29.9 (0.0–60.8)	69.0 (51.1–80.9)	46.7 (17.3–76.0)	65.4 (52.6–78.3)

Note: Shaded areas highlight results based on counts < 10. These results should be treated with caution.

Approximately 20% (19.0%; 16.6–21.4) of caregivers identified that travelling and waiting times contribute to making immunisation completion difficult (Table 9). This was significantly less likely to be a problem identified by caregivers of European/Other children (12.4%; 9.8–15.0) compared to other ethnic groups. Over 60% (62.5%; 54.5–70.4) of caregivers with English as a second language indicated that they would

understand more about immunisations if information were provided in their own language.

There were also other significant ethnic differences relating to statements regarding immunisation shown in Table 9. In summary, caregivers of Asian and Pacific children were more likely than caregivers of Māori and European/Other children to agree that a mild case of the disease builds up better protection, immunisations should be required before children enter school, immunisation records should be checked at school entry and doctors/nurses should provide more information about the benefits/risks of immunisation.

Caregivers of Māori, Pacific and Asian children were significantly more likely than caregivers of European/Other children to agree with a nurse coming to the home to vaccinate, that the child should be vaccinated at the same time as a visit to their child health nurse, and that it was hard to remember when children are due for immunisations. Caregivers of Pacific children were more likely than caregivers of European/Other children to agree that only people in certain areas need to have children immunised, and that it is unnecessary to have many injections since the diseases have died out. However, caregivers of Pacific (97.1%; 93.3–100.0) children were significantly more likely than caregivers of European/Other (87.0%; 84.5–89.5) children to agree that all childhood immunisations are important.

Table 10: Caregiver agreement that it is essential/desirable to be immunised against selected vaccine-preventable diseases, by ethnicity of child (percentage)

	Ethnicity				
Disease	**All**	**Māori**	**Pacific**	**European/ Other**	**Asian**
Diphtheria	88.2 (86.4–90.1)	89.7 (86.2–93.2)	86.5 (81.2–91.9)	87.7 (85.3–90.2)	89.0 (83.9–94.2)
English measles	84.5 (82.3–86.8)	87.1 (83.2–91.1)	89.5 (83.9–95.2)	82.7 (79.9–85.6)	84.7 (78.3–91.1)
Hepatitis B	92.9 (91.7–94.1)	94.7 (92.4–97.0)	95.0 (91.1–98.9)	91.5 (89.9–93.1)	95.3 (91.5–99.1)
Haemophilus influenzae type b	87.7 (86.0–89.3)	89.6 (86.3–92.8)	90.4 (85.8–95.0)	86.3 (83.8–88.8)	88.7 (81.8–95.6)
Mumps	87.8 (86.2–89.4)	90.7 (87.4–94.1)	88.6 (82.7–94.4)	86.5 (84.3–88.8)	87.1 (79.8–94.4)
Polio	91.7 (90.2–93.2)	91.7 (88.8–94.5)	89.9 (84.5–95.3)	91.8 (89.8–93.8)	92.7 (87.8–97.7)
Rubella or German measles	93.4 (92.1–94.7)	94.3 (91.9–96.7)	93.1 (88.5–97.8)	93.1 (91.3–94.9)	92.7 (87.5–98.0)
Tetanus	94.4 (93.1–95.7)	95.4 (93.3–97.5)	89.8 (83.6–96.0)	95.0 (93.4–96.6)	91.9 (86.9–97.0)
Whooping cough (pertussis)	93.1 (92.0–94.3)	94.2 (91.9–96.5)	92.7 (88.2–97.3)	92.9 (91.4–94.5)	91.9 (86.4–97.4)

Measles was the vaccine-preventable disease that the least proportion of caregivers (84.5%; 82.3–86.8) believed is essential/desirable to be vaccinated against (Table 10). This was significantly lower than the proportion of caregivers indicating that polio, tetanus, rubella, whooping cough and hepatitis B were essential/desirable to be vaccinated against. There were no significant ethnic or regional differences (data not shown) for these results.

Multivariable analysis

Univariate analysis

The univariate analysis looked at the association of individual variables on the fully immunised status of the child at age two years. Reference groups are provided for each variable and represented by a value of 1.0. All risk factors analysed in the univariate models were also run separately by the ethnicity of the child (Māori and non-Māori) and by the four health regions. However, only the results for the total population are presented in this section.

Household income

When compared with the reference group of principal household income not from a benefit, principal household income from a benefit decreased the likelihood of full immunisation by almost half (OR 0.53; 0.36–0.78) (Table 11). Low household income (less than or equal to $40,000) was associated with a significant lowering of the odds for being fully immunised at age two years (OR 0.60; 0.42–0.88) compared with households whose income was over $70,000.

Small area socioeconomic deprivation

The effect of small area socioeconomic deprivation on the immunisation status of two-year-old children was examined using the New Zealand 2001 Deprivation Index (Crampton et al 2004). Results are presented using quintiles of deprivation matched to the address of the survey respondent. The reference group used was the least deprived quintile. The only significant effect was a reduced odds ratio for being fully immunised at age two years in children living in quintile 4 (OR 0.57; 0.37–0.88) (Table 11). This relationship was not significant for children living in quintile 5.

Ethnicity of the principal caregiver

If the caregiver identified as Māori, when compared with the reference group of caregivers identifying as non-Māori, there was a significant lowering of the likelihood of the child being fully immunised at age two years (OR 0.53; 0.39–0.71) (Table 11).

Table 11: Univariate variables and the association with fully immunised status at age two years (odds ratio)

Variable	Odds ratio	95% CI
Principal household income		
Not from a benefit	1.0	
From a benefit	0.53*	0.36–0.78
Household income		
≥$70,001	1.0	
$40,001–$70,000	0.77	0.51–1.16
≤$40,000	0.60*	0.42–0.88
Socioeconomic deprivation (NZDep2001 quintiles)		
1 (least deprived)	1.0	
2	0.62	0.35–1.10
3	0.82	0.49–1.39
4	0.57*	0.37–0.88
5 (most deprived)	0.62	0.39–1.01
Ethnicity of principal caregiver		
Non-Māori	1.0	
Māori	0.53*	0.39–0.71
Number of household moves since birth		
< 2	1.0	
≥ 2	0.43*	0.32–0.58
Age of principal caregiver		
≥ 25 years old	1.0	
< 25 years old	0.63*	0.41–0.98
Living status of principal caregiver		
Living with others	1.0	
Living alone	0.61*	0.38–0.97
Qualification level of principal caregiver		
Secondary or tertiary qualification	1.0	
No formal education	0.64*	0.46–0.89

* $p < 0.05$.

Household mobility

To examine the effect of household mobility on immunisation status, the number of times a household had moved since the birth of the child was used. The reference group was less than two household moves since the birth of the child. If the household had moved on two or more occasions since the birth of the child, this was a significant and strong predictor of incomplete immunisation at age two years (OR 0.43; 0.32–0.58) (Table 11).

Age of principal caregiver

Analysis of the effect of caregiver age on immunisation status used the reference group of 25 years old and over and compared this to those caregivers under 25 years old. The under-25 years category was associated with only 60% of the chance of being fully immunised at age two years when compared to a child with an older caregiver (OR 0.63; 0.41–0.98) (Table 11).

The univariate analysis was also run with three categories of age (under 25 years, 25 to 39 years and 40 years and over, reference group 25 to 39 years) to determine if older caregivers have an effect on immunisation status. The rationale for this came from the background literature review, which showed that both younger and older caregivers have been associated with the risk of incomplete immunisation (Sharland et al 1997). There was no significant effect of older caregivers on immunisation status at age two years (data not shown).

Living status of principal caregiver

Caregivers were asked whether they were living with a partner, living alone, or living with others. A caregiver living alone was compared with the reference group of a principal caregiver not living alone (caregiver living with a partner or others). A caregiver living alone was significantly associated with a risk of incomplete immunisation for the child (OR 0.61; 0.38–0.97) (Table 11).

Qualification level of principal caregiver

Results are presented using the group of caregivers who had obtained a secondary or tertiary qualification as the reference group, compared with caregivers having received no formal qualification. A caregiver with no formal school or other qualification was significantly associated with a lowering of the odds ratio (OR 0.64; 0.46–0.89) for being fully immunised at age two years (Table 11).

Because the background literature review had demonstrated that both high and low education levels are associated with incomplete immunisation (Essex et al 1995; Hull, Lawerence et al 2001; Hull, McIntyre et al 2001; Haynes and Stone 2004; Paterson et al 2004), different models were used to determine if higher education level has an effect on immunisation status. Tertiary education compared with the reference group of having achieved better than NCEA Level 1(or equivalent)[11] but less than tertiary qualification showed no significant lowering of the odds ratio for being fully immunised (data not shown). However, the effect of lower educational achievement of a child's principal caregiver persisted in this three-level analysis of caregiver qualification by decreasing the likelihood of the child being fully immunised at age two years.

[11] National Certificate of Educational Achievement Level 1 or New Zealand School Certificate in one or more subjects, or National Certificate Level 1.

Multivariable model

The variables to include in the multivariable model were chosen on the basis of the background literature review of the most likely risk factors for incomplete immunisation, and based on the multivariable analysis conducted in the previous New Zealand regional coverage surveys in 1991/92. In addition, evidence of the association of each variable on immunisation status from the univariate analyses was used to determine which variables to use in the multivariable model. Many variables could affect the immunisation status of a child, and it was not possible within the scope of this survey to examine all of these possibilities and combinations.

The final model included the following six variables that are associated with the likelihood of full immunisation status at age two years:

- total household income
- caregiver qualifications
- number of household moves since the birth of the child
- caregiver age
- caregiver ethnicity
- caregiver living status.

Logistic regression was used to determine the association of each of these variables with full immunisation status of children aged two years old, while controlling for all of the other variables included in the model. The results are shown in Table 12.

Table 12: Multivariable analysis of fully immunised status at age two years (odds ratio)

Variable	Odds ratio	95% CI
Household income		
≥ $70,001	1.0	
$40,001–$70,000	0.85	0.56–1.30
≤ $40,000	0.82	0.55–1.21
Ethnicity of principal caregiver		
Non-Māori	1.0	
Māori	0.60*	0.41–0.87
Number of household moves since birth		
< 2	1.0	
≥ 2	0.46*	0.33–0.64
Age of principal caregiver		
≥ 25 years old	1.0	
< 25 years old	1.06	0.63–1.80
Living status of principal caregiver		
Living with others	1.0	
Living alone	1.01	0.56–1.83
Qualification level of principal caregiver		
Secondary of tertiary qualification	1.0	
No formal education	0.83	0.55–1.24

* $p < 0.05$.

From the multivariable analysis, two variables remained significant in lowering the odds ratio of being fully immunised at age two years: two or more household moves since the birth of the child (OR 0.46; 0.33–0.64) and the principal caregiver's ethnicity being identified as Māori (OR 0.60; 0.41–0.87). These variables appear to be risk factors for incomplete immunisation at the age of two years.

This model was also run separately for each of the four health regions. Ethnicity of the principal caregiver was no longer significant, and only in the Northern and Central–Southern regions was two or more household moves a significant variable (results not shown).

A number of other models were run using different variable combinations and different numbers of categories within the variables, but the consistent finding was of a significant decrease in the odds ratio of being fully immunised at age two years with two or more household moves.

Discussion

Coverage levels

Since the previous New Zealand national coverage survey in1991/92 there have been a number of coverage level targets set and strategies devised and implemented. The most recent was *Immunisation in New Zealand: Strategic directions 2003–2006* (Ministry of Health 2003). This document reiterated targets set by the former Public Health Commission in 1994 with the aim of achieving 95% coverage overall, with Māori matching non-Māori coverage levels, and increased coverage in areas or populations with low coverage to within 10% of overall population coverage by 2005. These aims were to be achieved via the following steps:

- implementation of the National Immunisation Register
- introduction of the MeNZB vaccination programme
- developing effective communication and a promotion strategy for immunisation as a key component of child and adult health through:
  - strategic national leadership and co-ordination
  - a sustainable financing strategy
  - surveillance, disease control and outbreak preparedness
  - strengthening immunisation policy
  - workforce development
  - research and evaluation.
- reducing inequalities in coverage and improving access through:
  - outreach immunisation services
  - PHO development
  - supporting whānau ora
  - enhancing opportunistic immunisation
  - enhancing and increasing linkages to well child providers.

Although there has been an improvement in coverage levels over the previous 13–14 years (Table 13) this survey suggests that the current coverage levels of 77.4% (75.3–79.5) at age two years and 82% (80.6–84.6) at the time of the survey still fall significantly below the 90–95% level required for control of vaccine-preventable diseases. Perhaps more concerning are the persisting ethnic inequalities. It appears that the inequalities between Pacific and European/Other people are no longer significant, but there are persisting inequalities in coverage for Māori compared with European/Others. Similar ethnic inequalities have been found from analysis of the MeNZB campaign.[12] Although the analysis by ethnicity was not presented in full for the 1991/92 surveys (the surveys was not designed to have sufficient numbers for ethnic analysis), it is possible to compare Māori coverage with total population coverage.

[12] See http://www.immunise.moh.govt.nz/newsletters/newsletter-1205.pdf.

This comparison appears to show that inequalities have decreased between 1992 and 2005 in both absolute (~18% to 8%)[13] and relative terms (ratios of 1.4 to 1.1)[14] (Table 13). The analysis of coverage levels suggests that the majority of the remaining inequality may be due to the contribution from incomplete vaccination of the 15-month vaccines.

Table 13: Comparison of immunisation coverage results (fully immunised at age two years), from 1992, 1996 and 2005 coverage surveys (percentage)

Ethnicity	1992 national survey %	1996 North Health survey % (95%CI)	2005 national survey % (95% CI)
All	< 60	63.1 (59.1–67.1)*	77.4 (75.3–79.5)
European/Other	Not available	72.3 (67.5–77.1)	80.1 (77.4–82.9)
Māori	42.0	44.6 (35.5–53.7)	69.0 (63.7–74.3)
Pacific	45.0	53.1 (43.7–62.5)	80.7 (73.7–87.6)
Asian	Not available	Not available	79.8 (71.4–88.2)

Notes: *Not significantly different from 1992 figures for Northern region. Figures for Māori and Pacific peoples were not presented in the 1992 report but were presented in subsequent articles without confidence intervals because the survey was not designed to provide good estimates for ethnic coverage levels. Caution should therefore be exercised when using these figures.

It is important to remember that total coverage levels do not accurately reflect inequalities in coverage; for example, high total coverage levels may not reflect the same level of coverage for Māori. It is also important to note that ethnicity alone does not drive coverage levels, and that national coverage levels cannot reflect successful local initiatives. For example, Māori have the lowest coverage of all ethnic groups nationally (ie 69%; 63.7–74.3 full immunised at age two years), but for Lakes DHB, which has a high proportion of population identifying as Māori, there is a suggestion of good coverage levels for Māori and no significant ethnic inequalities in coverage (81.9%; 55.2–100.0 for Māori and 87.3%; 74.8–99.8 for non-Māori fully immunised at age two years).[15] Lakes DHB have attributed their success to the use of enrolled populations, good recall systems and outreach services to high-risk children (Pert 1999).

Of significant concern are the low coverage levels achieved on time, as defined by the recommended schedule. These often did not improve significantly even when adjusting for the recommended interval between sequential doses. The concern is that late vaccination is associated with incomplete vaccination. In addition, even if vaccines are eventually completed late, this leaves a group of children vulnerable for longer periods

[13] From the 1991/92 survey, the absolute difference in coverage between the total population and Māori was 60.0% – 42.0%, which is 18.0% and from the 1996 survey it was 63.1% – 44.6%, which is 18.5%. In comparison, from the 2005 survey the difference was 77.4% – 69.0%, which is 8.4%.

[14] From the 1991/92 survey, the relative difference between the total population and Māori was 60.0% compared with 42.0%, with the total population having 1.4 times greater coverage than Māori and from the 1996 survey it was 63.1% compared with 44.6%, which is also 1.4. In contrast, from the 2005 survey the relative difference in coverage was 77.4% compared with 69.0%, which is 1.1.

[15] This analysis is from the survey, but has not been presented because many of the ethnic proportions for individual DHBs involved very small numbers.

than when immunisation is completed at the recommended age, increasing the potential for epidemics or outbreaks of vaccine-preventable disease.

Immunoprophylaxis with hepatitis B immunoglobulin and hepatitis B vaccine at birth followed by three doses of vaccine at six weeks, three months and five months can prevent the transmission of hepatitis B in over 90% of babies born to hepatitis B positive mothers. Therefore, the aim of the immunisation programme should be to achieve 100% coverage for neonatal immunoprophylaxis. Despite the importance of achieving full coverage, local reviews have found that the immunoprophylaxis falls short of 100%.[16]

The findings from this survey of 72% (53.5–90.5) coverage confirm that a very effective preventive measure such as hepatitis B immunoprophylaxis is still failing to reach the desired 100% coverage. Despite the wide confidence intervals associated with the survey results, where there is concern that 100% coverage is not being achieved the system needs to be carefully examined for how to improve delivery.

Immunisation in New Zealand: Strategic directions 2003–2006 (Ministry of Health 2003) suggested an aim for BCG vaccination coverage of 80% of eligible infants by 2005.[17] It was not possible from this survey to assess the proportion of infants who would be eligible for BCG, and therefore impossible to present an estimate of how actual coverage levels compare with the recommended levels. The three DHBs with the highest proportion of children vaccinated with the BCG vaccine (Auckland, Counties Manukau and Capital and Coast) contain the three highest proportions of Pacific and Asian ethnicities of all DHBs. Pacific and Asian infants are likely to be eligible for BCG vaccination, and therefore the BCG coverage appears to reflect the underlying eligible population.

Reasons for missed vaccinations and caregiver knowledge and attitudes

Caution is required when using the reasons given for missing vaccinations and caregiver attitudes to immunisation to seek explanations for low coverage or inequalities in coverage (especially ethnic inequalities), given the small numbers involved. However, a number of themes emerged relating to the reasons for missed vaccinations, in particular, concurrent illness in a child (that may or may not have been considered mild) and concern about vaccine side-effects. Although this concern was significantly higher among European/Other caregivers, this does not appear to affect the overall immunisation coverage level for this group. European/Other caregivers were also more likely than Māori and Pacific caregivers to believe that any serious side-effects from vaccination occur rarely. This may be a reflection of other support systems available to European/Other caregivers or the ability to access further information for reassurance.

[16] Regional Public Health, Hutt Valley DHB (2001) Review of neonatal Hepatitis B prophylaxis in Wellington. Unpublished; Public Health Protection, Auckland DHB (2001). Improving Hepatitis B immunisation coverage in high-risk infants in Auckland. Unpublished.

[17] See the *Immunisation Handbook 2002* (Ministry of Health 2002) for neonatal eligibility criteria.

There is clearly a desire for more information to be provided in other languages by the caregivers in this survey. However, the background literature review has shown that providing information and education to caregivers alone is not associated with improvement in immunisation, and this approach needs to be supported by a whole package of strategies to boost immunisation coverage levels.

The MMR vaccine has one of the lowest coverage levels. An explanation for this may be that English measles is also associated with the least proportion of caregivers believing it is essential/desirable to be vaccinated against this disease. However, rubella was associated with a higher proportion of caregivers believing this is a disease that is essential/desirable to be immunised against, and yet rubella is part of the same vaccine as measles (the MMR vaccine). Beliefs and attitudes are not the only explanation for low coverage levels.

Multivariable analysis and risk factors for incomplete immunisation

In the 1991/92 multivariable analysis the model contained the following variables: principal household income from a benefit; Māori and Pacific ethnicity of the caregiver; principal caregiver without a formal school qualification; two or more family moves since birth of child; and caregiver less than 25 years old. The significant findings for a decreased odds ratio of being fully immunised at age two years were: household income from a benefit for the Northern and Central–Southern Regional Health Authorities (RHA); child's principal caregiver not achieving school certificate for the Northern RHA; and a caregiver identifying as Māori for the Northern RHA.

The additional variable, caregiver living status, was included in the multivariable model for the 2005 survey analysis, based on the background literature review (Sharland et al 1997; Bond 1999b; Hull, McIntyre et al 2001; Haynes and Stone 2004). Although all the individual variables were significant risk factors for incomplete immunisation at age two years old, when placed in the multivariable model only the variables two or more household moves and a caregiver identifying as Māori remained significant. Two or more household moves was not identified as a significant risk factor in the 1991/92 survey analysis. The significant findings from the multivariable analysis in the 1991/92 survey were not replicated in the 2005 survey when examined by health region (results not shown). However, a caregiver identifying as Māori was a significant risk factor for note being fully immunised for all regions in the 2005 survey.

The risk factor of increased household mobility may be a reflection of the inability of local recall/reminder systems to function when children move away from their primary medical care or Well Child provider. A system such as the National Immunisation Register will be able to improve vaccination coverage, because a centralised database can help to overcome issues with lack of continuity of care, and can support an opportunistic vaccination approach.

Although socioeconomic variables were independently associated with an increased risk of incomplete immunisation, these variables were no longer significant when included in the multivariable model. Therefore the focus for improving immunisation should remain on interventions that improve coverage for mobile families and on how the system can be more responsive to Māori children. It is likely that prioritisation by ethnicity will be the most effective strategy for reducing inequalities in coverage. Different approaches are required for different ethnic groups, and the analysis of attitudes to vaccinations clearly shows some differing preferences between different ethnic groups; for example, caregivers of European/Other children were less likely to want home visits to complete vaccinations compared with caregivers of Māori or Pacific children.

The reasons for the significant reduction in inequalities of immunisation coverage for Pacific children from 1991/92 compared with the lesser improvement for Māori children cannot be determined from this survey. This appears to have occurred despite a similar socioeconomic and demographic profile for both ethnic groups. This will be an important area to explore further, because it is clear that strategies employed for Pacific peoples have been successful, and innovative approaches are needed to achieve similar improvements for Māori children.

Conclusion

It is encouraging that immunisation coverage for two- to three-year-old children has significantly improved since the previous New Zealand national coverage survey in 1991/92 (77.4% compared with less than 60% for fully immunised status at age two years). However, there is still a need to improve the coverage level for all children towards the target level of 95% at age two years. Coverage levels remain higher for vaccines received at a younger age, and improving coverage of the 15-month vaccines should be a priority.

The persisting ethnic inequalities are of concern, and therefore it is important to look at initiatives to improve immunisation coverage for Māori children. This requires working alongside Māori to provide solutions. There is evidence from the high levels of coverage obtained for DHBs such as Lakes DHB that working with the community and targeted approaches can be successful in improving coverage for Māori children. In addition, improving coverage for Māori children has the potential to improve immunisation coverage for all New Zealand children, as all children may benefit from such initiatives.

This survey could not look at all the factors that might influence the level of vaccine coverage. For example, factors such as geographic distance from health providers will influence coverage levels obtained in some areas. However, the significant findings of household mobility and children of Māori caregivers being at risk of incomplete immunisation at age two years provide some guidance for targeting resources to improve coverage levels.

Multiple strategies are required to improve immunisation coverage, including:

- improved access, such as the use of alternative settings for vaccine delivery
- providing clear and balanced information on the risks and benefits
- reduced costs
- effective recall systems, with feedback on coverage levels.

The National Immunisation Register can begin to address the last aspect, initially by reviewing coverage levels of the early vaccines and, with time, vaccinations at all ages. In addition, the development of PHOs, which are responsible for the immunisation of their enrolled populations, also aims to improve coverage levels.

The National Immunisation Register can provide information on coverage levels without the need to conduct a national coverage survey. With a tool such as this it will be possible to evaluate the success of any strategy implemented to improve childhood immunisation coverage. This survey has provided a snapshot of the coverage of two- to three-year-old New Zealand children in 2005, and can be used alongside future National Immunisation Register coverage estimates to assess the effectiveness of interventions introduced to improve vaccination coverage in this age group. In addition, the coverage levels estimated by this survey can be used as a baseline to assess what impact use of the National Immunisation Register has on improving coverage levels.

Appendix 1: Methodology

Introduction

Aims

The aims of the survey were to:

- measure national immunisation coverage of two- to three-year-olds as a baseline for the National Immunisation Programme
- measure any change in immunisation coverage since the previous survey and identify any inequalities in coverage
- examine data on caregivers' attitudes to immunisation.

The survey aimed to define the nature and extent of immunisation coverage in New Zealand. Accurate population measures are necessary to highlight areas of immunisation need in New Zealand and to monitor any trends in coverage since 1992.

Background

This survey was previously conducted in 1991/92 under the auspices of the New Zealand Communicable Disease Centre, using a survey approach largely informed by the World Health Organization (WHO) Programme on Immunisation, among two- to three-year-olds. This study sought to preserve continuity with the earlier study, but this time greater emphasis has been placed on obtaining more robust estimates for Māori and Pacific peoples.

Analysis of the coverage survey results will be widely disseminated by the Ministry of Health to District Health Boards (DHBs), primary care providers, other immunisation service providers and the general public.

The survey was funded by the Ministry of Health – public health funding.

The National Research Bureau (NRB) was contracted to design and field the survey. The NRB's role included designing the sampling methodology, piloting the questionnaire, obtaining ethical approval, interviewing respondents, processing data, and providing a data set with appropriate documentation to the Ministry of Health.

Survey design methodology

Design requirements

Accuracy requirement

A requirement for this survey was to achieve a minimum accuracy level of ±3% for national results, ±6% for Māori and ±8% for Pacific peoples. These accuracies are specified in terms of sampling errors. The sampling errors are represented by 95% confidence intervals. The 95% confidence interval of a survey estimate provides an indication of the margin of sampling error for that estimate. In 95 out of 100 samples the true population value will lie within these confidence intervals.

Sample size requirements

A requirement for this survey was to:

- cognitively test the questionnaire on a minimum of 25 participants to ensure the questions were understood and were able to be answered in a way the Ministry intends
- obtain a final sample size of at least 1400 responding eligible children.

Response rate requirements

A requirement for this survey was a minimum weighted response rate of 75% of eligible households.

Population and sampling frame

Target population

The target population was the New Zealand population of children aged two and three years old living in permanent private dwellings. The target population was approximately 107,000 children according to the 2001 New Zealand Census of Population and Dwellings (2001 Census).

The study looked at immunisation coverage of the primary series of immunisations up to the age of two years. Children sampled were two or three years old, reflecting immunisations given one to three years ago. This survey was restricted to this age group to make it comparable with the 1992 survey and to reflect international study design, and this age group is considered to be of primary importance for service planning.

Survey population

Geographic coverage: For practical reasons a few households that were part of the defined target population were excluded from participating in the survey, but were accounted for in the final estimates via the survey weights. These included households not resident on the main islands of New Zealand (North, South and Waiheke), such as those located on other offshore islands, on-shore islands, waterways and inlets.

In addition, all meshblocks had to contain nine or more households and a non-zero count of children aged two or three years at the time of the 2001 Census. This restricted the eligible population to 98.6%.

Dwellings coverage: The survey covered the eligible population living within permanent, private dwellings. Private dwelling types that were not included in the survey were temporary private dwellings such as caravans, cabins or tents in a motor camp, or boats. All non-private dwellings were excluded from the survey such as hotels, motels, guest houses, boarding houses, homes for older people, hostels, motor camps, hospitals, barracks and prisons.

Eligible respondents: All children aged two or three years old who were usually resident within permanent private dwellings were eligible for selection as respondents. The term 'usually resident' excluded people who were present within the dwelling at the time of interview but who usually resided elsewhere (either within New Zealand or overseas).

Sample frame

The survey frame was a national area-based frame comprising the list of small geographic areas (meshblocks) defined by Statistics New Zealand that fell within the geographical coverage of the survey. Meshblocks were the primary sampling units (PSUs). The survey frame provides the first stage in the sampling process that proceeds to dwelling selection within the meshblock and then respondent selection within the dwelling. The procedure for this selection process is described in the sample design section (see below).

All New Zealand households were geographically clustered to avoid having to list and maintain a frame of all households in the country. Lists of dwellings were only enumerated within the selected meshblocks. The cost of interviewing was reduced because the selected households were geographically clustered and therefore travelling costs were reduced.

Sample design

The survey used a complex sample design to provide high-quality estimates for minimal cost and acceptable respondent burden. Population characteristics from the 2001 Census were used in the sample design and sample selection.

The survey used a complex stratified multi-stage clustered design. The first stage of sampling was selection of the primary sampling units – in this case meshblocks. The population of meshblocks was grouped into two strata, according to the 2001 Census:

- stratum 1 (high density): meshblocks containing Pacific peoples at a density of 10% or more of the population
- stratum 2 (low density): meshblocks containing Pacific peoples at a density of less than 10%.

Meshblocks were selected with equal probability of selection within each stratum. A higher sampling fraction was chosen for stratum 1 compared to stratum 2, due to the need to obtain a larger proportion of Pacific peoples in the sample than naturally exists in the population.

The second stage of sampling was the selection of households within each meshblock. Lists of dwellings were enumerated within selected geographic areas and screened for eligible children. Thus, all households within each selected meshblocks were screened for those containing an eligible child. The third stage of sampling was the selection of one eligible child. To minimise respondent burden and clustering effects (as each child in the same household is likely to experience similar treatment), only one eligible child was selected from each sampled dwelling. Where two or more eligible children resided in a dwelling, one was chosen by a random procedure called the Kish grid.

Accuracy designed for

The sample was designed to yield robust estimates of immunisation coverage for Māori, based on a minimum of 250 Māori children, yielding ±6% confidence intervals at 95%, and for Pacific ± 8%, and other ethnicities ± 3%.

Table A1-1: Intended accuracy of survey design

	Ethnicity		
	Māori	**Pacific**	**European/ Other**
Design effects:			
Due to cluster size	Negligible	Negligible	Negligible
Due to selection weights	1.17	1.15	1.10
Precision designed for at 95% confidence level	± 6%	± 8%	± 3%
Estimated gross sample sizes of respondents:			
From stratum 1	153	159	207
From stratum 2	214	21	762
In total	367	180	969
Effective sample sizes of respondents after design effects (deffs) accounted for	314	156	881

Questionnaire

A standard questionnaire was administered by the interviewer to each parent or caregiver. Interviewers collected information on the demographic characteristics of the child and caregiver, vaccinations received by the child, reasons for any missed or incomplete vaccinations, and the caregiver's attitudes towards and understanding of vaccine-preventable diseases and immunisation.

Data collection

Collection mode (method)

The collection mode chosen was face-to-face interviewing using trained interviewers. The 1992 survey also used face-to-face interviewing. Data were collected from the principal caregiver for the selected child. These people have the best ability of anyone to provide the required information.

The survey used normal WHO methodology, which is to report on medical history confirmed by medical records (where consent to view medical records has been given by the respondent), and medical history reported by respondents (where consent to view medical records has not been given by the respondent).

The respondent was asked about the immunisations that had been received by the eligible child. This was verified by sighting the *Well Child Tamariki Ora Health Book.* Where the book was lost or missing, written permission was asked to view the child's immunisation record only, at the relevant GP's or doctor's practice. If neither of these sources was available, caregiver recall of vaccination was recorded.

Interviewer selection, training and performance

Selection of interviewers: Selection of competent interviewers is a key step to obtaining a good response rate. The NRB analyses each survey it conducts in terms of the individual response rate achieved by each interviewer. Factoring in the demographics of the areas, interviewers are ranked on their ability to achieve responses.

Training and in-field support: Interviewers need to have a strong sense of 'entitlement' to approach homes, a strong sense of the 'value of the survey' to sell participation to the household, and a versatile selection of 'engagement options' with which to ensure they can find a compromise between the eligible person's time/place/attitude configuration, and the time required for the interview. Interviewers and field supervisors receive formal training on how to conduct interviews. Field supervisors also receive additional training in contact and support with interviewers and progress and evaluation forms for interviewers. Interviewers worked under supervision and were required to report any adverse event to their supervisor.

Performance: The interviewers' performance was regularly monitored. They were rewarded for applying their training successfully.

Respondent choice: Respondents of a particular ethnic group may prefer an interviewer of the same ethnic background, in which case the NRB complied by providing such a person, where possible. Interviewers were briefed on cultural perspectives.

Call pattern

In addition to good interviewer preparation, the call pattern is an important component of achieving a high response. Calls to households were made in such a way as to ensure working mothers/principal caregivers were included. Specifically, calls to a given home included both week and weekend days and evenings. Call-backs were suitably spaced to ensure that persons away from their dwelling had a high chance of being captured. Appointments were also taken for interviews to allow for respondents to choose a more convenient time. The NRB conducted up to six calls at each dwelling before accepting that dwelling as a non-contact dwelling.

Interview process

The interviewer first established the languages spoken in the household. From experience the NRB have found there is generally at least one person resident who has sufficient English to give the mother's/principal caregiver's preferred language. If a translator was required, the interviewer would then arrange this for another day.

The eligible person did not need to decide to participate on the same day. The interviewer would return at a mutually arranged day and time to determine whether the person would take part.

Consent

The survey was voluntary. Adults asked to complete the questionnaire were told about the survey and provided with an information brochure. If they agreed to take part they were asked to sign a consent form.

Each adult was asked to provide the details of the child's GP so that information could be released regarding immunisations the child has received and the mother's hepatitis B carrier status. Similarly authorisation was sought from the manager of the hospital in which the child was born to release information regarding any immunisations given to the child at birth and the mother's hepatitis B carrier status.

Field dates

The survey was conducted from January to March 2005.

Field test

Although no field test was undertaken, testing of the systems and a cognitive test of the questionnaire were completed. The decision not to undertake a field test was based on a number of factors: (a) the survey had been conducted previously; (b) NRB's experience with running similar large-scale surveys; (c) the limited resources available, in terms of time and funding.

Sample size selected

A total of 630 meshblocks were selected, of which responses were received from 516. For stratum 1, a sample of 150 meshblocks was selected, of which responses from 134

were received. For stratum 2, a sample of 480 meshblocks was selected, of which responses from 382 were received.

According to the 2001 Census the average number of eligible households in each meshblock was:

- 4.6 per meshblock in stratum 1
- 2.8 per meshblock in stratum 2.

To verify that the selected meshblocks would yield sufficient numbers of children (in particular Māori and Pacific peoples), the selected meshblocks were analysed according to their demographics from the 2001 Census. The NRB sourced from Statistics New Zealand counts of the numbers of households with children aged two or three, and those under two years.

In all 28,780 dwellings were visited, with responses received from 1563 eligible children of whom 439 were Māori, 239 Pacific peoples and 136 Asian. These are total response ethnicity counts, where children who were reported as belonging to more than one ethnic group are counted in each group they reported.

Response rate and respondent load

Response rate

The unweighted response rate for the survey was 84%, in terms of dwellings. Responses were received from 1563 dwellings from an estimated total of 1851 eligible dwellings (ie, dwellings where a child aged two or three usually resides). The breakdown of contact outcomes is shown in Table A1-2.

Table A1-2: Contact outcomes from household dwellings visited

Contact outcome	Number of dwellings
Eligible responding interviews	1563
Vacant	1094
Household refusal	39
Respondent refusal	151
No reply	289
Not available to interview when interviewer visited	34
Unavailable for entire period of survey	23
Appointment	1
Language	29
Other	4
No access	113
Household not eligible	25,440
Total	**28,780**

Interview duration

The median time taken by participants to complete the interview was 25 minutes, with the lower and upper quartiles being 20 and 30 minutes and the longest 99 minutes.

Measures used to maximise response and minimise respondent load

The survey and processes were carefully designed to ensure the impact on respondents was minimised. The following measures were used to maximise the response rate.

- Only one eligible child was selected per dwelling.
- A well-tested and largely well-proven questionnaire was used.
- Skilled interviewers carried out the interviews.
- Appointments were made for interviews.
- Interviews were accepted away from the dwelling in special circumstances.
- Well-designed call pattern processes were used.
- Interviewers had in-field support.
- Interviewers were monitored and, if found to be under-performing, were retrained or replaced.

Data processing

The NRB was responsible for data capture, editing and coding.

Data capture

The data collected via a pen and paper questionnaire were captured electronically. Personally identifiable data was not entered in the electronic form.

Editing

The unit record data set provided to the Ministry was edited mainly for range and logic errors. Any inconsistencies found were remedied by returning to the questionnaire and, if necessary, to the respondent for clarification and correction.

Overall a number of edits were undertaken, including:

- field editing by area supervisors to ensure completion of the questionnaire
- supervisors re-contacting respondents if data were missing
- running an electronic edit to ensure no duplication of serial numbers or ineligible serial numbers, and then reverting to the paper questionnaire if an error was found
- running an electronic check over the branching ‘skip to’ instructions throughout the questionnaire to identify overfills for removal and underfills for return to the field for follow-up (generally by phone)

- running an electronic range check to ensure all data fell within the permissible code range, then checking the questionnaire or re-contacting the respondent if necessary
- checking the range and logic to identify inconsistencies, then checking the questionnaire or re-contacting the respondent if necessary.

Imputation

No explicit unit record or item imputation was used in the survey to deal with unit record or item non-response. However, non-response has been implicitly adjusted for in the weighting estimation by benchmarking the survey population to an estimate of the target population using 2001 Census counts.

Coding

Most of the questions used a single tick box, although some questions offered an 'other' category, where respondents could specify non-standard responses. Each other category response was recorded and later analysed. Each response was either categorised to an existing code, coded to a newly set up 'standard' code or coded as other. Some questions also allowed multiple responses. For these questions, all responses were retained, with each response shown as a separate variable on the data file (ie, Q26_01, Q26_02, Q26_03, etc).

Quality control

Quality control of data and processes was an integral component of the survey's implementation. It was implemented through comprehensive testing, ongoing performance monitoring, peer review, using standard classifications and concepts (where possible), and using specialist staff.

Interviewers

Quality control of interviewers meant interviewers:

- were selected after taking a written test and having a personal interview to screen for above-average aptitudes
- received explicit stepwise training in each identified task and risk element
- were tested after training to check on their uptake and retention
- were monitored in the field and, when necessary, were removed and replaced if under-performing.

Field work

Quality control of the field work meant:

- field checking of a sample of completed interviews to ensure fidelity
- an area supervisor monitoring and counselling on in-the-field issues day by day
- support to the field interviewers from a trouble-shooter at head office to raise the field success rate
- checking the address of each interview to ensure each interviewer had not strayed outside their given meshblock
- continuously monitoring the response rate per meshblock
- matching the language, culture or gender of an eligible respondent and an interviewer to minimise non-response bias
- field editing by area supervisors to ensure completion of questionnaires.

Processing

Quality control of the processing meant:

- range and logic edits to reduce inconsistencies
- creating tables of estimates to check that the results are sensible
- creating a data dictionary, which includes a detailed description of each variable and response value.

Weighting estimation

The survey was conducted on only a sample of eligible children, so each child represents a number of other children in the population. Therefore, each child is given a weight to indicate how many population units are represented by the sample unit. Survey weights allow the sample to be used to produce estimates for the entire population. Weighting takes into account the individual probability of selection, but allows one to calibrate (align) the survey weights to independent known population totals. Not every child had the same probability of section: Pacific and Māori children had a greater chance of selection so that more reliable estimates could be produced.

Selection weight

The selection weight is the sample design weight associated with the initial probability of selection. For each of the two strata the probability of selecting a child = W1 x W2,

where:

W1 = is the probability of selecting the primary sampling unit (ie, meshblock). This is the number of meshblocks selected in the sample divided by the number of meshblocks in the population.

For stratum 1: W1 = (150/4771).
For stratum 2: W1 = (480/33594).

W2 = the probability of selecting one eligible child per household. This is one divided by the number of eligible children in the household (ie, the number aged two or three).

The inverse of the probability of selection is the selection weight. In other words, the selection weight is one divided by the probability of selection.

Final weighting (calibration)

The final stage of the weighting process is a weighting adjustment to ensure the final weighted totals of eligible respondents are consistent with independent population estimates. The survey was benchmarked to 2001 Census population counts.

A post-stratification adjustment was made to ensure the final weighted totals of eligible children were consistent with independent population counts from the 2001 Census. The post-stratification adjustment was done within each stratum. For each stratum the post-stratification factors were calculated by prioritised ethnicity (three groups prioritised in order: Māori, Pacific peoples, and European/Other) by deprivation index quintiles. In stratum 2, due to small sample counts, Pacific peoples and European/Other ethnicities were aggregated together for deprivation index quintile 5. This post-stratification adjustment also adjusts for under-coverage in the frame and non-response, and reduces the level of sampling error for benchmark variables.

Replicate survey weights

Replicate survey weights have also been produced for calculating the sampling error for each survey estimate. These replicate weights simulate a scenario, where instead of having just taken one sample, we have G additional samples, from which we can determine the variability due to sampling.

The full sample is divided up into G 'homogeneous' groups. G sub-samples are produced by deleting one group at a time from the full sample. Each member of the full sample is assigned to a group in a way that mirrors the sample design. This is done so that each sub-sample replicates the design of the full sample, but contains slightly fewer members. Each sub-sample is then re-weighted to the population based on the same weighting estimation methodology as for the full sample.

Data reliability

Two types of error are possible in an estimate based on a sample survey: sampling error and non-sampling error.

Estimates from this survey are subject to *sampling error* or variability because they are based on information relating to a sample of persons rather than a full enumeration. That is, they may differ from the results that would have been produced if all the information had been obtained for all people. The method for calculating the sampling errors is outlined below.

Other inaccuracies can occur because of insufficient coverage of respondents, inadequacies and imperfections in answers provided by respondents, and errors made when coding and processing data. Such inaccuracies are referred to as *non-sampling errors* and may occur in any survey, regardless of whether it is a sample or full enumeration. Significant effort is made to reduce non-sampling error by carefully designing and testing the survey, questionnaire and processes, and ensuring detailed quality control of procedures and data.

Calculation of sampling errors

The delete-a-group jack-knife method (Kott 1998) can be used to calculate sampling errors for survey estimates. The idea behind the replication approach is to divide the sample into G random groups, and then estimate the variance of the full sample survey estimate. For this survey, 100 random groups were chosen (G = 100). The delete-a-group jack-knife method works as follows.

For each estimate another G replicate estimates are calculated using the G replicate weights. The variance of the full sample statistic is estimated using the variability among the G replicate estimates. This is done by taking the sum of the squared differences between the G replicate estimates and the original full sample estimate, and multiplying this by (G–1)/G.

To summarise, the formula for calculating the variance of an estimate using this method is:

$$\text{variance } (y) = \frac{(G-1)}{G} \times \sum_g (y_g - y)^2$$

where:

G = 100 (the number of replicate groups)
g = 1, 2, ..., G
y_g = weighted estimate, having applied the weights for replicate group g
y = weighted estimate from the full sample.

For the 95% confidence interval:

$$\text{Sampling error}(y) = 1.96 \times \sqrt{\text{variance}(y)}$$

Confidence interval (y) = y ± sampling error (y).

The near unbiasedness of the delete-a-group jack-knife requires the number of first-phase samples in each stratum to be large; say, greater than five.

Classifications and standards

Standard classifications have been used, where appropriate, to promote comparability and data consistency.

Security of information

Any information collected in the survey that could be used to identify individuals has been treated as confidential. Names and addresses of people and households collected in the survey have not been stored with their responses. Data were collected via a pen and paper questionnaire, which were then captured electronically. Personally identifiable data, such as contact details (name, address and phone number), were not captured in the electronic form.

No information will be released in a way that would enable an individual or a household to be identified.

Unit record data are stored in a secure area and are accessible on a restricted 'need to know' basis only. All applications by academics or researchers to access anonymised unit record files will be assessed according to predefined criteria. If successful, applicants will be required to sign an agreement to ensure no breach of confidentiality occurs with regard to the storage of, and access to, the data and their outputs.

Appendix 2: Construction of the Health Regions

Table A2-1: Construction of the health regions according to District Health Board (DHB) and number of respondents (n)

Northern		Central–Northern		Central–Southern		Southern	
DHBs	**n**	**DHBs**	**n**	**DHBs**	**n**	**DHBs**	**n**
Auckland	179	Bay of Plenty	75	Capital and Coast	102	Canterbury	122
Counties Manukau	194	Lakes	65	Hawke's Bay	79	Otago	54
Northland	48	Tairawhiti	23	Hutt	58	South Canterbury	14
Waitemata	169	Taranaki	47	MidCentral	50	Southland	49
		Waikato	139	Nelson Marlborough	48	West Coast	6
				Wairarapa	23		
				Whanganui	19		
Total	**590**		**349**		**379**		**245**

Appendix 3: Data Tables

Table A3-1: Fully immunised coverage at different end points, by ethnicity of child (percentage)

Ethnicity	Coverage at age 1 year	Coverage at age 2 years	Coverage at time of survey	Coverage on time	Coverage on time (interval-adjusted)
Total	82.1 (80.0–84.3)	77.4 (75.3–79.5)	82.6 (80.6–84.6)	39.0 (36.3–41.6)	42.4 (39.7–45.1)
Māori	75.6 (70.6–80.6)	69.0 (63.7–74.3)	78.0 (73.6–82.4)	29.9 (24.6–35.3)	33.5 (28.1–38.9)
Pacific	83.1 (75.8–90.5)	80.7 (73.7–87.6)	87.5 (81.8–93.3)	32.0 (23.9–40.1)	37.0 (28.1–46.0)
European/ Other	84.5 (81.9–87.2)	80.1 (77.4–82.9)	82.6 (75.1–90.1)	41.4 (37.8–45.1)	44.5 (40.9–48.2)
Asian	83.6 (76.0–91.2)	79.8 (71.4–88.2)	83.8 (81.2–86.4)	57.1 (48.6–65.6)	60.6 (52.0–69.2)

Table A3-2: Fully immunised coverage at different end points, by health region (percentage)

Health region	Coverage at age 1 year	Coverage at age 2 years	Coverage at time of survey	Coverage on time	Coverage on time (interval-adjusted)
Total	82.1 (80.0–84.3)	77.4 (75.3–79.5)	82.6 (80.6–84.6)	39.0 (36.3–41.6)	42.4 (39.7–45.1)
Northern	80.8 (77.2–84.5)	75.8 (72.0–79.6)	81.5 (77.7–85.2)	37.1 (32.9–41.3)	40.1 (36.3–43.8)
Central–Northern	80.1 (75.0–85.1)	76.6 (70.4–82.8)	83.3 (78.2–88.5)	36.9 (31.4–42.5)	39.4 (33.6–45.2)
Central–Southern	82.4 (78.4–86.4)	76.9 (72.4–81.3)	80.8 (76.8–84.7)	38.4 (32.6–44.3)	42.9 (37.4–48.5)
Southern	87.0 (82.3–91.8)	82.3 (77.1–87.6)	86.1 (81.4–90.9)	46.3 (39.9–52.7)	50.4 (43.4–57.4)

Table A3-3: Fully immunised coverage at different end points, by District Health Board (DHB) (percentage)

DHB	Coverage at age 1 year	Coverage at age 2 years	Coverage at time of survey	Coverage on time	Coverage on time (interval-adjusted)
New Zealand	82.1 (80.0–84.3)	77.4 (75.3–79.5)	82.6 (80.6–84.6)	39.0 (36.3–41.6)	42.4 (39.7–45.1)
Auckland	86.1 (80.0–92.3)	78.0 (71.5–84.5)	84.1 (77.7–90.5)	42.1 (34.6–49.6)	43.1 (35.2–50.9)
Bay of Plenty	78.6 (67.3–89.9)	76.2 (65.2–87.1)	85.8 (79.0–92.5)	28.5 (15.9–41.1)	31.0 (18.1–44.0)
Canterbury	88.1 (82.5–93.6)	80.7 (73.4–88.1)	84.4 (78.0–90.9)	45.5 (35.3–55.8)	48.3 (38.7–57.8)
Capital and Coast	81.4 (72.0–90.8)	75.5 (64.3–86.7)	80.4 (71.1–89.7)	38.4 (29.3–47.4)	44.1 (34.4–53.8)
Counties Manukau	82.1 (76.8–87.4)	76.3 (68.8–83.8)	81.5 (74.8–88.2)	38.3 (30.0–46.6)	45.0 (37.8–52.2)
Hawke's Bay	81.1 (70.8–91.4)	72.9 (59.7–86.0)	75.4 (63.5–87.2)	35.3 (23.0–47.6)	38.6 (26.9–50.4)
Hutt	87.9 (79.9–96.0)	82.3 (72.3–92.3)	87.1 (78.8–95.4)	38.8 (18.5–59.1)	41.3 (21.3–61.4)
Lakes	85.6 (78.9–92.3)	84.6 (67.7–100.0)	87.6 (74.1–100.0)	44.8 (33.9–55.7)	46.7 (36.1–57.2)
MidCentral	86.1 (77.1–95.0)	86.2 (77.0–95.4)	91.2 (82.8–99.7)	44.4 (24.2–64.7)	47.9 (30.1–65.8)
Nelson Marlborough	85.0 (70.2–99.8)	80.7 (63.2–98.3)	84.8 (73.8–95.7)	49.7 (35.0–64.3)	55.7 (41.8. 69.7)
Northland	71.2 (54.0–88.3)	64.9 (49.5–80.3)	77.0 (64.8–89.2)	21.7 (8.5–34.8)	25.6 (14.1–37.1)
Otago	73.5 (58.9–88.2)	74.2 (60.2–88.1)	78.2 (64.3–92.0)	43.0 (30.8–55.2)	46.8 (33.6–60.0)
South Canterbury	93.7 (80.6–100.0)	93.7 (80.6–100.0)	93.7 (80.6–100.0)	(–)	(–)
Southland	94.5 (88.9–100.0)	88.9 (82.2–95.6)	94.5 (88.9–100.0)	49.4 (36.3–62.4)	55.7 (39.7–71.7)
Tairawhiti	78.3 (33.0–100.0)	64.3 (41.1–87.4)	76.1 (48.3–100.0)	(–)	(–)
Taranaki	87.4 (77.9–96.9)	83.7 (70.8–96.5)	85.6 (74.3–96.9)	48.7 (34.0–63.5)	52.7 (36.5–68.9)
Waikato	75.8 (67.3–84.2)	72.2 (62.9–81.5)	80.0 (70.6–89.4)	37.6 (26.5–48.7)	40.1 (29.6–50.6)
Wairarapa	81.0 (63.0–99.0)	72.8 (50.1–95.5)	72.8 (50.1–95.5)	(–)	41.3 (19.6–63.1)
Waitemata	78.1 (70.2–86.0)	76.9 (68.7–85.0)	80.6 (72.0–89.3)	36.5 (28.9–44.0)	37.2 (29.8–44.6)
West Coast	(–)	(–)	(–)	(–)	(–)
Whanganui	63.0 (39.4–86.7)	55.2 (38.0–72.4)	60.5 (35.5–85.5)	(–)	(–)

Note: A dash (–) indicates results were not provided because the count was < 10.

Table A3-4: Individual vaccine coverage at age one year, by vaccine dose and ethnicity of child (percentage)

Vaccine dose	Total	Māori	Pacific	European/Other	Asian
Fully immunised	82.1 (80.0–84.3)	75.6 (70.6–80.6)	83.1 (75.8–90.5)	84.5 (81.9–87.2)	83.6 (76.0–91.2)
DTaP dose 1	91.1 (89.6–92.6)	88.1 (84.5–91.7)	95.6 (93.2–98.1)	91.6 (89.5–93.8)	91.4 (86.1–96.7)
DTaP dose 2	89.3 (87.7–90.9)	84.2 (80.4–88.0)	92.6 (88.1–97.1)	90.7 (88.5–92.9)	90.9 (85.3–96.4)
DTaP dose 3	84.7 (82.6–86.9)	76.4 (71.3–81.5)	85.3 (78.3–92.2)	87.9 (85.3–90.5)	86.8 (80.0–93.6)
Oral polio or DTaP-IPV dose 1	91.0 (89.5–92.5)	88.1 (84.5–91.7)	95.6 (93.2–98.1)	91.7 (89.5–93.8)	89.9 (84.5–95.3)
Oral polio or DTaP-IPV dose 2	89.0 (87.4–90.6)	84.2 (80.4–88.0)	91.4 (86.1–96.6)	90.6 (88.4–92.8)	89.4 (83.7–95.0)
Oral polio or DTaP-IPV dose 3	84.6 (82.5–86.7)	76.4 (71.3–81.5)	85.3 (78.3–92.2)	87.8 (85.2–90.4)	85.8 (79.0–92.6)
Hib dose 1	90.2 (88.7–91.8)	87.9 (84.2–91.5)	94.4 (90.8–98.1)	91.0 (88.8–93.1)	87.7 (81.5–93.9)
Hib dose 2	88.6 (87.0–90.2)	84.2 (80.4–88.0)	91.4 (86.1–96.6)	90.3 (88.1–92.5)	86.8 (80.5–93.2)
Hep B dose 1	89.3 (87.8–90.9)	87.7 (84.1–91.4)	93.3 (89.1–97.5)	89.3 (87.0–91.6)	90.0 (84.5–95.5)
Hep B dose 2	87.3 (85.6–89.0)	84.1 (80.3–87.9)	89.8 (84.0–95.5)	88.4 (86.1–90.6)	86.8 (80.6–92.9)
Hep B dose 3	82.4 (80.3–84.6)	75.6 (70.6–80.6)	83.1 (75.8–90.5)	85.0 (82.3–87.7)	84.0 (76.9–91.1)
Neonatal Hep B + HBIG	72.0 (53.5–90.5)	(–)	(–)	(–)	(–)

Notes: A dash (–) indicates results were not provided because the count was < 10. The numerator for 'fully immunised' included two children that had no record of receiving neonatal HBIG when the mother was identified as being a carrier of hepatitis B. They did, however, go on to receive all three subsequent doses of Hep B vaccine.

Table A3-5: Individual vaccine coverage at age two years, by vaccine dose and ethnicity of child (percentage)

Vaccine dose	Total	Māori	Pacific	European/Other	Asian
Fully immunised at age 2	77.4 (75.3–79.5)	69.0 (63.7–74.3)	80.7 (73.7–87.6)	80.1 (77.4–82.9)	79.8 (71.4–88.2)
DTaP dose 1	92.1 (90.9–93.4)	90.8 (88.2–93.5)	96.1 (93.6–98.6)	92.1 (90.1–94.1)	92.4 (87.7–97.0)
DTaP dose 2	90.6 (89.3–92.0)	87.0 (83.4–90.5)	95.1 (92.5–97.7)	91.5 (89.5–93.5)	90.9 (85.3–96.4)
DTaP dose 3	88.6 (87.0–90.3)	84.2 (80.4–88.1)	89.1 (83.4–94.8)	90.3 (88.1–92.5)	90.0 (84.4–95.7)
DTaP dose 4	79.3 (77.2–81.5)	70.2 (65.0–75.4)	83.7 (77.8–89.6)	82.3 (79.6–85.0)	81.1 (73.1–89.1)
Oral polio or DTaP-IPV dose 1	92.1 (90.8–93.4)	90.8 (88.2–93.5)	96.1 (93.6–98.6)	92.1 (90.1–94.2)	91.4 (86.6–96.1)
Oral polio or DTaP-IPV dose 2	90.4 (89.0–91.8)	87.0 (83.4–90.5)	93.9 (90.1–97.6)	91.4 (89.4–93.4)	89.9 (84.3–95.5)
Oral polio or DTaP-IPV dose 3	88.5 (86.8–90.1)	84.2 (80.4–88.1)	89.1 (83.4–94.8)	90.2 (88.0–92.3)	88.5 (82.8–94.3)
Hib dose 1	91.3 (89.9–92.6)	90.6 (87.8–93.4)	94.9 (91.2–98.5)	91.4 (89.3–93.5)	88.7 (83.3–94.1)
Hib dose 2	90.0 (88.5–91.4)	87.0 (83.4–90.5)	93.9 (90.1–97.6)	91.0 (88.9–93.0)	87.7 (81.5–93.9)
Hib dose 3	79.6 (77.5–81.6)	71.0 (65.8–76.3)	84.2 (78.6–89.9)	82.3 (79.7–84.9)	81.2 (73.0–89.3)
Hep B dose 1	90.6 (89.2–91.9)	90.4 (87.6–93.3)	93.7 (89.5–98.0)	90.1 (87.9–92.3)	91.0 (86.1–95.9)
Hep B dose 2	88.9 (87.4–90.4)	86.8 (83.3–90.4)	92.3 (87.9–96.7)	89.4 (87.2–91.6)	87.6 (81.6–93.6)
Hep B dose 3	86.5 (84.8–88.3)	83.6 (79.6–87.5)	87.9 (82.0–93.9)	87.5 (85.1–89.9)	86.8 (80.6–93.0)
MMR dose 1	82.0 (79.8–84.1)	73.4 (68.2–78.6)	85.2 (79.5–91.0)	84.5 (81.8–87.3)	86.0 (78.6–93.5)
Neonatal hep B + HBIG	72.0 (53.5–90.5)	(–)	(–)	(–)	(–)

Notes: A dash (–) indicates results were not provided because the count was < 10. The numerator for 'fully immunised' included two children that had no record of receiving neonatal HBIG when the mother was identified as being a carrier of hepatitis B. They did, however, go on to receive all three subsequent doses of Hep B vaccine.

Table A3-6: Final dose coverage at age two years, by District Health Board (DHB) (percentage)

DHB	DTaP dose 4	Oral polio or DTaP-IPV dose 3	Hib dose 3	Hep B dose 3	MMR dose 1
All	79.3 (77.2–81.5)	88.5 (86.8–90.1)	79.6 (77.5–81.6)	86.5 (84.8–88.3)	82.0 (79.8–84.1)
Auckland	83.7 (78.2–89.2)	89.9 (85.1–94.7)	83.1 (77.8–88.3)	88.4 (83.0–93.7)	83.9 (78.3–89.6)
Bay of Plenty	78.7 (69.4–88.1)	93.0 (86.9–99.1)	78.7 (69.4–88.1)	90.5 (84.2–96.8)	78.8 (68.0–89.6)
Canterbury	82.3 (75.3–89.3)	90.4 (85.3–95.4)	82.3 (75.3–89.3)	88.8 (83.2–94.3)	88.5 (82.3–94.7)
Capital and Coast	76.7 (65.0–88.4)	86.9 (78.9–94.9)	76.7 (65.0–88.4)	85.7 (77.8–93.6)	80.8 (70.5–91.2)
Counties Manukau	77.5 (70.3–84.8)	86.7 (81.7–91.8)	79.0 (71.9–86.0)	86.3 (81.2–91.4)	81.1 (74.1–88.2)
Hawke's Bay	76.7 (64.1–89.4)	88.1 (78.2–98.1)	75.3 (62.3–88.4)	84.6 (74.3–94.9)	78.2 (64.8–91.7)
Hutt	82.3 (72.3–92.3)	92.4 (85.0–99.9)	82.3 (72.3–92.3)	87.9 (79.9–96.0)	84.3 (74.1–94.5)
Lakes	86.1 (71.2–100.0)	90.0 (79.3–100.0)	86.1 (71.2–100.0)	88.5 (76.4–100.0)	86.1 (71.2–100.0)
MidCentral	86.2 (77.0–95.4)	95.5 (88.9–100.0)	87.4 (78.7–96.1)	93.3 (85.6–100.0)	90.4 (82.6–98.2)
Nelson Marlborough	85.2 (65.7– 100.0)	91.3 (82.7–99.9)	87.4 (72.2–100.0)	87.0 (75.6–98.4)	85.2 (70.7–99.6)
Northland	64.9 (49.5–80.3)	81.1 (71.4–90.8)	64.9 (49.5–80.3)	81.1 (71.4–90.8)	68.9 (53.1–84.7)
Otago	74.2 (60.2–88.1)	88.9 (77.3–100.0)	76.0 (61.9–90.2)	84.9 (73.4–96.5)	84.9 (74.0–95.8)
South Canterbury	93.7 (80.6–100.0)	93.7 (80.6–100.0)	93.7 (80.6–100.0)	93.7 (80.6–100.0)	93.7 (80.6–100.0)
Southland	88.9 (82.2–95.6)	94.5 (88.9–100.0)	88.9 (82.2–95.6)	94.5 (88.9–100.0)	88.9 (82.2–95.6)
Tairawhiti	64.3 (41.1–87.4)	83.1 (48.0–100.0)	64.3 (41.1–87.4)	83.1 (48.0–100.0)	64.3 (41.1–87.4)
Taranaki	83.7 (70.8–96.5)	94.1 (87.2–100.0)	83.7 (70.8–96.5)	87.4 (77.9–96.9)	87.9 (76.8–99.1)
Waikato	74.6 (64.6–84.6)	82.8 (75.0–90.7)	74.6 (64.6–84.6)	82.8 (75.0–90.7)	75.2 (66.1–84.3)
Wairarapa	72.8 (50.1–95.5)	81.0 (63.0–99.0)	72.8 (50.1–95.5)	81.0 (63.0–99.0)	81.0 (63.0–99.0)
Waitemata	78.9 (71.3–86.6)	87.2 (81.1–93.2)	79.7 (72.6–86.7)	83.7 (76.0–91.3)	81.4 (73.0–89.9)
West Coast	(–)	(–)	(–)	(–)	(–)
Whanganui	60.5 (35.5–85.5)	74.7 (45.5–100.0)	55.2 (38.0–72.4)	69.5 (48.8–90.1)	60.5 (35.5–85.5)

Note: A dash (–) indicates results were not provided because the count was < 10.

Table A3-7: Reasons given by caregivers for missed immunisations (percentage)

Reason	%
Risk associated with immunisation	25.2 (19.4–31.0)
Different schedule / immunisation done overseas	19.1 (13.4–24.7)
Medical reasons	11.0 (6.8–15.2)
Child believed to be vaccinated but records do not show it given	8.1 (4.7–11.6)
Concern about a particular vaccine	5.3 (2.2–8.5)
Do not believe vaccines work	3.2 (1.0–5.4)
Forgot to get it done	2.5 (0.3–4.7)
No reason given	2.5 (0–5.4)
Too busy	2.4 (0.6–4.2)
Not sure if child is vaccinated and records do not show it given	2.3 (0.3–4.3)
Behind schedule / catching up	1.7 (0–3.4)
Lack of knowledge	1.7 (0.0–3.3)
Child experienced reaction to earlier vaccine	1.5 (0.0–3.5)
Not had vaccinations done yet/will get it done soon	1.5 (0.0–3.1)
Made informed choice not to immunise / do not agree with / do not believe in immunisation	1.4 (0.0–3.0)
Too young for immunisations	1.3 (0.0–2.7)
Too far to travel / difficulty getting there	1.2 (0.0–2.5)
Moved away / moving a lot	1.2 (0.0–2.9)
Prefer to let immune system work naturally	0.9 (0.0–2.1)
Just lazy / can not be bothered / have not got around to it	0.9 (0.0–2.0)
Do not like to see child in pain / crying	0.7 (0.0–1.6)
The cost	0.4 (0.0–1.1)
Other	4.2 (1.1–7.2)

Note: Shaded areas are based on counts < 10 (so caution is required with interpretation).

Table A3-8: Caregiver's response to immunisation statements, by ethnicity of child (percentage)

Statement	Response	Ethnicity				
		All	Māori	Pacific	European/ Other	Asian
A reminder such as a letter/ telephone call when children are due for immunisations would be helpful	**Disagree**	7.2 (5.7–8.7)	6.3 (3.9–8.7)	4.6 (0.1–0.9)	8.1 (5.9–10.3)	6.6 (1.8–11.4)
	Agree	91.5 (89.9–93.0)	92.2 (89.3–95.1)	94.9 (90.4–99.5)	90.7 (88.4–93.0)	91.7 (86.3–97.0)
All childhood immunisations are important	**Disagree**	6.6 (5.5–7.7)	5.7 (3.2–8.2)	1.7 (0.0–3.6)	7.9 (6.1–9.6)	4.9 (1.0–8.7)
	Agree	89.1 (87.3–90.8)	91.2 (88.1–94.3)	97.1 (93.3–100.0)	87.0 (84.5–89.5)	89.5 (84.0–95.0)
Diseases like these can be serious to young children	**Disagree**	0.7 (0.2–1.1)	0.3 (0.0–0.8)	2.3 (0.0–4.9)	0.6 (0.0–1.1)	0.8 (0.0–2.5)
	Agree	98.1 (97.3–98.8)	98.5 (97.1–100.0)	93.3 (89.1–97.5)	99.0 (98.3–99.7)	94.9 (90.0–99.7)
Doctors/nurses seem to be firmly in favour of immunisation for children	**Disagree**	2.7 (1.8–3.6)	1.3 (0.3–2.3)	2.0 (0.0–4.7)	3.6 (2.1–5.1)	0.8 (0.0–2.4)
	Agree	92.5 (91.0–94.1)	93.9 (91.5–96.3)	93.7 (89.7–97.7)	91.9 (89.7–94.1)	91.8 (85.6–97.9)
Doctors/nurses should provide more information on the benefits/risks of immunisation	**Disagree**	27.6 (25.0–30.2)	22.0 (17.2–26.7)	9.7 (5.3–14.2)	34.8 (31.2–38.4)	10.7 (4.6–16.7)
	Agree	64.2 (61.3–67.1)	72.0 (67.5–76.4)	87.4 (82.3–92.5)	54.8 (50.7–58.8)	85.3 (77.9–92.6)
General immunisation helps to protect children who cannot be immunised themselves due to illness	**Disagree**	11.7 (9.9–13.4)	14.2 (10.1–18.2)	13.0 (8.0–18.0)	10.6 (8.5–12.7)	10.2 (4.0–16.4)
	Agree	75.8 (73.2–78.4)	71.2 (65.7–76.7)	73.2 (65.2–81.2)	78.1 (68.6–75.0)	76.3 (67.1–85.5)
Hard to remember when children are due for immunisations	**Disagree**	64.2 (61.9–66.4)	54.3 (49.3–59.2)	54.0 (44.8–63.2)	71.8 (68.6–75.0)	48.9 (40.3–57.5)
	Agree	33.7 (31.6–35.8)	42.7 (37.7–47.8)	44.4 (35.4–53.5)	26.3 (23.2–29.3)	49.4 (40.8–58.0)
Immunisation injections are too upsetting/painful for young children	**Disagree**	65.1 (61.9–68.3)	53.4 (47.6–59.1)	43.1 (34.3–52.0)	75.2 (71.1–79.3)	49.9 (39.4–60.4)
	Agree	29.1 (26.1–32.0)	40.1 (34.6–45.7)	52.2 (42.7–61.7)	19.4 (15.9–22.9)	41.5 (31.6–51.5)
Immunisation is free for all children	**Disagree**	2.4 (1.6–3.2)	2.8 (1.4–4.2)	1.2 (0.0–2.9)	2.4 (1.3–3.5)	1.9 (0.0–4.5)
	Agree	95.0 (93.7–96.3)	95.7 (93.8–97.5)	97.8 (95.6–100.0)	94.8 (93.2–96.4)	91.3 (86.2–96.4)
Immunisation records should be checked at school entry so vaccinations can be given to those who missed out	**Disagree**	15.3 (13.7–16.9)	11.3 (8.1–14.5)	3.1 (0.0–6.4)	20.3 (17.7–22.8)	4.1 (0.5–7.8)
	Agree	75.1 (73.0–77.2)	77.3 (72.7–81.9)	94.8 (90.5–99.0)	69.4 (66.5–72.4)	89.1 (83.5–94.8)
Immunisation can cause serious side-effects	**Disagree**	24.5 (22.1–27.0)	22.9 (18.4–27.4)	31.3 (21.0–41.6)	22.5 (19.3–25.6)	37.7 (29.5–45.8)

Statement	Response	Ethnicity				
		All	Māori	Pacific	European/ Other	Asian
	Agree	52.4 (49.6–55.3)	48.4 (43.3–53.4)	35.4 (26.9–43.9)	59.0 (55.2–62.8)	34.3 (26.0–42.7)
Immunisations should be required for all children before they enter school	**Disagree**	25.9 (23.6–28.2)	24.0 (19.5–28.5)	13.5 (6.5–20.4)	30.9 (27.6–34.3)	7.5 (3.0–11.9)
	Agree	62.7 (60.0–65.4)	66.0 (61.0–70.9)	82.3 (76.2–88.4)	55.4 (51.8–59.0)	85.9 (80.1–91.7)
Mild case of disease builds up better protection	**Disagree**	56.6 (53.5–59.7)	57.2 (51.5–62.9)	45.6 (36.8–54.4)	59.3 (55.6–63.0)	46.8 (37.6–56.1)
	Agree	16.9 (14.6–19.1)	12.9 (8.9–16.8)	31.6 (22.9–40.2)	14.6 (11.7–17.5)	30.4 (20.3–40.6)
No need for immunisation if child healthy	**Disagree**	90.1 (88.5–91.8)	88.6 (85.1–92.2)	79.1 (71.7–86.4)	92.2 (90.2–94.1)	91.9 (87.2–96.7)
	Agree	6.0 (4.7–7.2)	6.3 (3.6–9.0)	14.1 (7.4–20.8)	4.7 (3.2–6.3)	5.4 (1.6–9.3)
Only one injection is needed and the follow-up boosters can be skipped	**Disagree**	88.7 (86.8–90.6)	86.2 (82.1–90.3)	86.8 (80.4–93.3)	91.0 (88.7–93.2)	81.4 (73.5–89.3)
	Agree	2.2 (1.3–3.0)	2.3 (0.8–3.9)	6.0 (2.4–9.6)	1.1 (0.3–1.9)	5.3 (0.5–10.2)
Only people in certain areas need to have children immunised	**Disagree**	93.8 (92.4–95.2)	94.8 (91.7–97.9)	87.1 (81.3–93.0)	95.1 (93.5–96.7)	87.9 (81.9–93.9)
	Agree	3.9 (2.7–5.1)	3.3 (0.7–5.8)	10.9 (5.1–16.6)	2.7 (1.6–3.9)	7.1 (1.4–12.7)
Caregivers have a responsibility to ensure children are immunised to prevent diseases from spreading in the community	**Disagree**	5.8 (4.5–7.1)	5.9 (3.4–8.4)	2.2 (0.0–5.2)	6.9 (5.0–8.7)	0.8 (0.0–2.5)
	Agree	90.5 (89.0–92.1)	90.6 (87.3–93.8)	96.8 (93.6–100.0)	88.9 (86.6–91.3)	95.7 (92.0–99.5)
Serious side-effects from immunisations are rare	**Disagree**	7.5 (6.0–9.0)	9.7 (6.5–13.0)	10.8 (6.1–15.4)	6.4 (4.4–8.4)	5.1 (1.2–9.1)
	Agree	76.7 (77.2–78.9)	65.1 (73.7–69.6)	58.9 (83.3–67.3)	84.3 (75.0–87.0)	75.4 (78.0–83.9)
Child should not be taken for immunisation if has an illness/ mild cold	**Disagree**	31.5 (28.9–34.2)	35.3 (30.7–39.9)	47.5 (39.9–55.0)	26.4 (23.0–29.9)	40.4 (30.3–50.5)
	Agree	58.7 (55.7–61.6)	56.4 (51.4–61.4)	45.7 (37.6–53.8)	63.3 (59.4–67.2)	44.9 (35.0–54.9)
Travelling and waiting time at doctors makes it difficult to have children immunised	**Disagree**	77.0 (74.4–79.6)	67.7 (62.2–73.2)	67.2 (59.4–75.0)	84.0 (81.1–86.9)	64.5 (55.3–73.8)
	Agree	19.0 (16.6–21.4)	27.7 (22.6–32.7)	30.7 (23.1–38.3)	12.4 (9.8–15.0)	28.3 (19.5–37.2)
Unless vaccinated my child could catch diseases	**Disagree**	11.7 (10.0–13.4)	12.1 (8.7–15.6)	9.3 (5.0–13.5)	12.6 (9.9–15.4)	6.3 (2.3–10.3)
	Agree	81.4 (79.1–83.7)	78.3 (74.0–82.6)	85.3 (80.5–90.0)	82.7 (79.6–85.8)	76.7 (69.2–84.2)
Unnecessary to have many injections since the diseases protected against have died out	**Disagree**	82.3 (80.2–84.4)	79.0 (73.3–84.7)	65.2 (55.7–74.6)	87.7 (85.5–89.8)	71.4 (62.6–80.1)
	Agree	7.7 (6.3–9.1)	8.0 (4.9–11.2)	18.4 (11.3–25.4)	5.3 (3.8–6.8)	13.0 (6.3–19.7)

Statement	Response	Ethnicity				
		All	Māori	Pacific	European/ Other	Asian
Vaccines are effective in stopping children from catching diseases	**Disagree**	9.2 (7.5–10.9)	8.6 (5.4–11.7)	3.9 (1.1–6.6)	11.1 (8.7–13.5)	3.4 (0.0–6.9)
	Agree	80.0 (77.2–82.8)	79.1 (73.7–84.5)	88.9 (83.3–94.6)	78.5 (75.0–82.0)	84.2 (78.0–90.4)
Would rather have nurse come to house to give child immunisations than go to doctor's surgery	**Disagree**	57.3 (54.2–60.4)	45.2 (39.7–50.7)	47.9 (38.7–57.1)	65.6 (61.9–69.2)	44.2 (33.6–54.7)
	Agree	33.7 (31.0–36.4)	44.4 (38.5–50.2)	46.0 (37.3–54.8)	26.2 (23.0–29.4)	42.8 (33.4–52.2)
Would rather my child be immunised at the same time as a visit to their child health nurse	**Disagree**	42.2 (39.5–44.9)	32.9 (28.3–37.6)	30.6 (22.6–38.6)	49.4 (45.7–53.2)	29.7 (20.0–39.3)
	Agree	42.7 (40.0–45.4)	49.9 (44.3–55.5)	61.7 (53.1–70.3)	35.4 (32.1–38.7)	54.4 (45.2–63.6)
Caregivers with English as a second language						
Would understand more about immunisations if information was in my own language	**Disagree**	33.9 (26.6–41.3)	54.7 (22.8–86.5)	27.7 (16.3–39.1)	53.3 (24.0–82.7)	31.6 (19.3–43.9)
	Agree	62.5 (54.5–70.4)	29.9 (0.0–60.8)	69.0 (57.1–80.9)	46.7 (17.3–76.0)	65.4 (52.6–78.3)

Note: Shaded areas indicate results based on count < 10 (so caution is required with interpretation).

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