Immunisation Coverage Of the Western Cape Province

Household Survey 2005

Principal Investigator: Dr Joanne Corrigall

Student Number: CRR_DA003

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Faculty of Health Sciences

University of Cape Town

Supervisor: Dr David Coetzee

Department: School of Public Health, University of Cape Town

DECLARATION

I, Joanne Corrigall, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Foreword

In the Western Cape the health of our children is taken seriously. A priority is to prevent vaccine preventable diseases in children by increasing the vaccine coverage to 90% for one-year old children. This is the goal set for South Africa by the National Department of Health.

Presently problems exist with data collection, validation, flow of data and the population denominator and thus no accurate data exists for vaccine coverage.

During 2005 it was, to undertake a provincial household survey to determine the vaccine coverage. This is the first survey of this kind done in this province. The survey reached nearly 4 000 homes throughout the Western Cape Province.

The main motivation for this survey was to determine the baseline so that the problems can be addressed and the goal of 90% vaccine coverage achieved.

The findings of this survey provide and opportunity to improve immunization coverage in the Western Cape and to improve child survival in the province.

Our sincere thanks go to the community for allowing the survey team in to their homes and participating in this survey. I would also like to thank, the Comprehensive Health Directorate, the Principal Investigator and the survey team for a job well done.

Minister Pierre Uys
Provincial Minister of Health: Western Cape
Date:

Preface

Entering the homes of nearly 4000 South Africans across the Western Cape provides an opportunity for us not only to ask questions, but also to listen and observe. One of the most striking observations was the extent of poverty in this Province; too many families live in squalid unhygienic conditions, without flushing toilets, proper food or the means to improve their living conditions. People's skin colour still seems to determine how far away from the town centre they live, how much they earn, whether their street has a name and how easily they access basic services.

Also striking was the beauty of the Province, the warmth and generosity of so many of its people, the kindness of the poor who offered the fieldworkers water and encouragement and the absence of prejudice where one might expect it. This is the paradox of our new South Africa: the coexistence of the legacy of apartheid with the inherent potential for and movements towards societal prosperity.

In this context it is imperative that those concerned with South Africa's well being nurture initiatives that propel us towards an equitable future; such a prosperous future may only be attained by restoring basic human rights to all South Africans. In the context of child health, this means we must endeavour to provide safe drinking water, sanitation, refuse removal, shelter, nutrition and access to quality health care. This project provides an opportunity to address the health of our children; to honour the time and valuable information the people of the Western Cape have given us we must ensure that that we do not just listen, but *act*. We must respond to these findings with courage if we are to realize the vision of a health service that puts people first. Only then will this project have succeeded.

Thank you to the people of the Western Cape for participating in this survey and sharing your needs, concerns, hopes and suggestions. Such participation is vital if we are to ensure that every resident of the Province enjoys his or her right to health. Certainly this must begin in childhood, and providing access to immunisations is crucial to the realisation of this right.

Dr Joanne Corrigall

MBBCH (Wits) DMH (SA)
Principal Investigator and Project Manager
Child Health and EPI sub-directorate
Provincial Government of the Western Cape
Registrar, School of Public Health, University of Cape Town
Email: joannecor@gmail.com

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Abstract

Objective: To determine the routine immunisation coverage rates in children aged 12-23 months in the Western Cape and factors affecting immunisation coverage **Design**: Cross-sectional Household Survey using an adaptation of the '30x7' cluster survey technique (multi-stage sampling) **Setting**: Households across the Western Cape. **Subjects:** 3705 caregivers of children aged 12-23 months who had been living in the Western Cape for at least 6 months. **Outcome measures:** Vaccination Status (1=fully vaccinated, 0= partially vaccinated) as recorded on a Road to Health card or given by history. Factors affecting caregivers' vaccination behaviour established from a questionnaire. **Results:** The immunisation coverage was 76.8% for vaccines due by 9 months and 53.2% for vaccines due by 18 months. The reasons given for not being immunised were clinic-related factors (47%), lack of information (27%), caregiver being unable to attend the clinic (23%) and lack of motivation (14%). Of clinic factors cited, the two commonest factors were missed opportunities (34%) and being told by clinic staff to come back another time (20%). Factors enhancing coverage included possession of a Road-to-Health card, caregiver knowledge about vaccines and perceived attitude of clinic staff. Certain racial inequities in coverage were also apparent, particularly in the Boland-Overberg Region. **Conclusion:** While the coverage indicated that a lot of good work has been done, the coverage was insufficient to prevent outbreaks of measles and other common childhood conditions including polio. The coverage was too low to consider not running periodic mass campaigns for measles and polio. The reasons given by caregivers for their children not being immunized and factors associated with increased coverage are valuable pointers as to where interventions should be focused.

Contents

1. Introduction

1.1. The Expanded Programme on Immunisations: A global context

On the wave of the success of the smallpox vaccine in achieving global eradication of smallpox, the World Health Organisation (WHO) promulgated the Expanded Programme on Immunisations (EPI) in 1974[1]. It aimed to increase immunisation coverage and assist with the establishment of national vaccination programmes for tuberculosis, measles, polio, diphtheria, pertussis and tetanus in all countries across the globe. At this time, less than 5% of children in developing countries received routine immunisations and vaccine preventable diseases caused significant morbidity and mortality[1]. Considerable international public health efforts have resulted in a global immunisation coverage rate of more than 80%[2] with the World Health Organisation aiming to eradicate polio by 2009[3], and decrease Measles mortality by 90% by 2010[4].

The global immunisation coverage rate conceals between-country differences and specifically differences between 'developed' and 'developing' countries (Table 1). For example, all 699 cases of polio reported in the first half of this year occurred in developing countries[5]. Eradication appears a distant prospect given that polio remains endemic in six countries, and has re-established transmission in several more countries, notably those in Africa and the developing world[6]. Polio remains endemic especially in Nigeria and India and there is significant movement of people between South Africa and both these countries. Countries with inadequate immunisation coverage remain at risk as was dramatically illustrated in May 2006 when South Africa's neighbour Namibia when on the verge of being declared polio free, reported a large outbreak of polio with more than 90 reported cases and over 19 deaths[7].

	BCG	DPT3	OPV3	Measles
Global	85%	78%	79%	77%
Africa	75%	61%	64%	63%
South Africa	97%	76%	72%	82%

Table 1. Percentage of target population vaccinated, by antigen (2003)[2].

The rationale for mass vaccination

The spread of a disease, its potential to become epidemic or endemic is determined by the reproductive rate of the infectious agent, which is the number of cases caused by an infectious individual[8]. One of the major determinants of the reproductive rate, or propensity for spread, is the number of susceptible individuals in a population such that the greater the magnitude of immune (non-susceptible) individuals in a population, the lower the rates of infection in that population. To calculate the necessary levels of population immunity required to prevent an epidemic, one takes the inverse of the reproductive rate (immunity coverage required=1/Ro)[8]. As such, each vaccination programme sets their targets at the minimum level of immunity required to prevent an epidemic or endemic infection. Immunisation coverage levels below this calculated value mean that should exposure to the infectious agent occur an epidemic will ensue (presuming random mixing of individuals and an influx of new susceptibles or births).

The required level of immunity in populations to prevent epidemics of infectious diseases from occurring has been estimated as about 95% and 85% for measles and polio respectively[9]. However it should be noted that this can vary between countries and vaccines. In North America polio viruses were eliminated with a routine immunization of less than 80% with three doses of oral polio while in South America almost 100% coverage with 9 - 10 does were required for the same effect[10]. Routine administration of measles vaccine was commenced in South Africa in 1975, with the

current two dose schedule being introduced in 1995[11]. Following the introduction of the vaccine, periodic epidemics of measles continued to occur with notifications of measles in winter epidemic exceeding 20 000. Subsequent to the mass measles and polio campaigns in 1996 periodic epidemics still occur often health facility mediated, but only a few hundred cases are notified and the vast majority of young doctors and nurses have never seen a case of measles[11].

These observations are in line with epidemiological theory; increasing immunization coverage has been shown to result in a decreased reproductive ratio of the diseases vaccinated against (due to fewer non-immunes), an increase in the mean age at infection and an increase in inter-epidemic periods[12].

It is important to note that immunisation coverage is not synonymous with levels of immunity as vaccines administered are not always 100% effective; the most accurate determination of immunity is to test antigen levels in individuals[13]. Should this not be possible, immunisation documentation and/or history may be used as a proxy measure, but is likely to underestimate true levels of immunity[13].

Cost-efficiency of vaccinations in developing countries

Immunisation has been shown to be one of the most cost-effective interventions available[14]. It is important to note, however that the indirect benefits to health systems arising from these programmes form an essential part of the cost-benefit analysis[15]. As such, eradication programmes should aim to strengthen primary health care facilities, as the overall success of any eradication effort is dependent on this[15]. Similarly, eradication programmes should not place excessive demands on health workers as this will result in the diversion of resources away from other important health problems. Only by adopting an approach that seeks to strengthen health services, can the inevitable tensions between disease eradication and sustainable health development be abated[15]. This is vital to bear in mind in the

South African context where health services must cope with the 'quadruple burden of disease'.

Multivariate analyses have demonstrated that immunisation coverage is an independent predictor of under-five mortality in developing countries[16,17]; obtaining optimal coverage is therefore essential in achieving the Millennium Development Goals of reducing child mortality.

1.2. Western Cape immunisation coverage estimates from routine data

South Africa has adopted the Expanded Programme on Immunisations (EPI-SA) and aimed to "to achieve 90% coverage for each vaccine in the routine childhood immunisation schedule in each district, by the year 2005"[18] for children aged one year.

According to data from the District Health Information System in November 2003, South Africa had immunisation coverage of 79%, with the Western Cape having one of the lowest coverage of all the provinces at 69%[19]. In May 2004 the *Child Health and EPI sub-directorate* of the Western Cape utilised the routine administrative method to establish immunisation coverage rates in the province[20]; the Cape Metropole had to be excluded from the report due to the extent of missing data for this region. Excluding the Cape Metro region, a comparison of vaccination rates in the Western Cape Province from 2001 to 2004, shows an overall decline in fully vaccinated children from 92% in 2001 to 79% in 2004[20]. Overall, these data were thought to represent an overestimation of coverage given that the Demographic and Health Survey in 1998 measured immunisation coverage in the Western Cape at 64.2%[21]. A summary of immunisation coverage by Health Region can be seen in Table 2.

Health Regions of Western Cape	Census method	Live-birth method
Boland-Overberg	76%	87%
Southern Cape-Karoo	75%	80%
West Coast-Winelands	86%	106%

Table 2: Immunisation coverage of 3 of the Health Regions of the Western Cape Province for the period 1 January- 31 March 2004 comparing the use of census data versus live-birth data as the denominator. Metro excluded due to lack of data.

The reports on immunisation coverage all draw attention to the significant inaccuracies of both the numerator and denominator used to calculate immunisation coverage. As such it is difficult to establish whether the shortfall in coverage is due to data inaccuracies or coverage deficiency.

Importance of accurately determining immunisation coverage rates

If immunisation coverage is not maintained above 90% South African children will remain vulnerable to wild virus outbreaks. Given the current political crises in Africa and the consequent disruption of vaccination programmes[22], South African children are at significant risk of exposure to wild viruses. Knowledge of the immunisation coverage rate is essential for planning of services and resource allocation, which should target those areas with the lowest immunisation coverage. An evaluation of the ability of routine services to achieve vaccination targets is also key to determining the necessity for immunisation campaigns. Furthermore, immunisation coverage is a global indicator of child health and reflects the quality and accessibility of health services[19]. In the context of post-apartheid South Africa, comparing coverage across a range of social groupings (gender, race and socio-economic status) can assist in monitoring progress towards health service equity.

HIV and routine immunisation

In the context of the high prevalence of Human Immunodeficiency Virus (HIV) in sub-Saharan Africa, concerns were raised about vaccine failure due to immune-compromised hosts being unable to mount the necessary immune response to the vaccines; Helfand et al (2005) reviewed the evidence on the measles vaccine and concluded, however, that HIV does not pose an "insurmountable barrier" to the control of measles as primary and secondary failure of vaccines would be counteracted by the high mortality rate of children due to Auto-immune Deficiency Syndrome[23]. The authors note, however, that people infected with HIV may have prolonged shedding of wild-type measles virus, increased severity of infections and greater potential for serious adverse events following vaccination. Furthermore, changes in the characteristic clinical presentation may hamper surveillance efforts[23]. Obara et al (2004) also raise the possibility that severely immune-compromised people may develop polio disease if exposed to excreted live attenuated oral polio vaccine[24]. Further research in this area and the impact of antiretrovirals is warranted.

1.3. Factors influencing acceptance of childhood vaccinations

Streefland et al[25] (1999) distinguish three patterns of attitudes and behaviours related to vaccinations namely social demand, acceptance and non-acceptance. *Acceptance* can be defined as adherence to the vaccination schedule (as known to the caregiver of the child) and ranges from passive to active depending on the level of activity required to conform to the vaccination programme. *Social demand*, by contrast, represents an active process whereby community members request accessible and quality vaccination services. Non-acceptance refers to non-compliance resulting from beliefs about vaccinations to difficulty accessing vaccination services. It is important to note that these categories are less absolute

than implied, with gradations of acceptance, and are dynamic, with caregivers moving between categories of acceptance over time or according to vaccine[25]. Numerous factors impact on caregiver attitudes to vaccines may serve to differentially increase or decrease acceptance, social demand or non-acceptance. As most of the research to date has focused on the barriers to immunization[26], there is limited knowledge on factors that increase social demand. Successful health promotion requires a thorough knowledge of both impeding as well as enhancing factors. Evidence from the literature has been organised as factors operating at the individual, societal, cultural, health service and political levels. These levels were conceptualised for convenience and are likely to be interdependent rather than mutually exclusive.

Individual level factors

Lack of information on or knowledge about vaccines[27,30], lack of trust in the health providers, government and/or vaccine technology[28], and concerns about vaccine safety[29] have been to show to result in poorer caregiver attitudes towards vaccinations. Maternal factors are the most extensively researched with maternal age, employment status[30], and maternal education[31] associated with vaccine acceptance. There have been some cursory studies evaluating paternal factors, with one study indicating the positive effect of paternal education on vaccination status[32]. Social inequality is reported to have effects on vaccination status, with some studies showing negative effects of low socio-economic status [32,33], female gender [34-35] and migration[36-37] on vaccination status. Lastly, in terms of the health belief model, the perceived risk of vaccine-preventable diseases has also been shown to influence vaccinating behaviour[38].

Societal and cultural level factors

Streefland[25] et al speak of a 'local vaccination culture', which consists of the normative social beliefs and behaviours surrounding immunisations in a particular community. This 'culture' is influenced by the community's past experiences with vaccinations, the media and societal beliefs about biomedicine and the nature of disease aetiology[38]. Alternative belief systems, such as the emergence of anti-vaccination ideology associated with New Age and naturalistic belief systems that are concerned with potential side-effects of vaccines in the context of the minimal risk of EPI diseases [39] would fall into this category. Social capital may play a role, with community levels of trust in those "advocating" vaccines influencing caregiver attitudes[25,26]. Gender biases have also been reported in India with female children less likely to be vaccinated than male children, which is thought to be due to male children being more valued than girl children[40].

Health service level factors

Health service level factors are those elements of heath service provision that have an impact on the likelihood of vaccination and include inaccessibility of vaccination sites, missed opportunities, vaccines not being available at the clinics, waiting times and so forth[5]. Beyond these logistical issues related to availability of vaccination services, the effects of the nature of health systems in general and the impacts on these systems by concurrent problems (such as AIDS) are important to consider[15,25]. Perceived support received from immunisation clinics has also been noted to influence vaccinating behaviour[41].

Political factors

These factors can be conceived of as those determinants of vaccination behaviour resulting from power differentials, typically suspicion of the motives of more

powerful groups e.g. The lack of trust in the producers of vaccinations resulted in the boycott of polio vaccinations in Nigeria in 2004, where the vaccines were thought to be an American plot to cause AIDS or infertility in Muslims[42]. It would also include societal responses to the degree of prescriptiveness of vaccination programmes[39]. In Apartheid South Africa, wide racial inequalities were evident in the immunisation coverage rates of children of different race-groups mirroring the racial disparities of Apartheid South Africa[43].

1.4. Previous immunisation coverage surveys in South Africa

The Demographic and Health Survey in 1998 measured immunisation coverage in the South Africa at 63%[21]. On a smaller scale, immunisation coverage surveys have suggested that coverage is around 70%; a community-based survey in the Dikgale-of Northern Province in 2000 estimated immunisation coverage of 12-23month old children before and after an immunisation campaign. Coverage was found to be 79% before the campaign, however this increased after the campaign to more than 90% for all vaccines except measles, for which coverage was 85%[44]. A study conducted in Mpumulanga Province in 1997 indicated that 71.1% (64.9-78.5) of 12-23 month old children were fully immunised[45].

There is minimal contemporaneous data on factors affecting vaccination attitudes in South Africa. The Mpumulanga study indicated that the main reasons for non-immunisation were 'obstacles to immunisation' (49%) (which included lack of availability of vaccines (9%), the distance of vaccination sites being too far (7%), illness of the child (6%)) followed by lack of information (on need for and timing of vaccines) (30%) and finally lack of motivation (21%)[45]). In the Dikgale Soekmekaar District, reasons cited for missing vaccines were lack of information, fear of complications, negative attitude nurses, no time to go for vaccines, vaccines not available, illness of child, distance of clinic and lack of motivation or having forgotten to take the child for vaccines[41]. Missed opportunities have been shown to

be common. A cross-sectional study comparing preventive and curative services at a Community Health Centre in Khayelitsha in 1993 found that 15.7% (9.2-22.2) of children attending preventive services that should have been vaccinated did not receive these vaccinations at their visit, whereas in the curative services 92% (85.9-98.1%) of children needing vaccines were not vaccinated[46].

A qualitative study on perceptions of childhood immunisations in rural Transkei indicated that parents had little knowledge about vaccinations and the diseases they protect against; given the small sample size (60 isiXhosa-speaking rural women) and lack of representivity, these results merit further research[47]. Given the paucity of information on factors determining vaccination status in the Western Cape, this area is identified as a gap in the literature.

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2. Aims and Objectives

2.1. Aims

The purpose of this study was to accurately determine the immunisation coverage rates of children aged 12 to 23 months in the six districts of the Western Cape Province with a view to evaluating progress towards the EPI-SA target of 90% immunisation coverage and identifying districts with sub-optimal immunisation coverage that require targeted intervention. In addition to this primary aim, the study aimed to identify factors influencing caregivers' decisions about routine childhood vaccines so that factors facilitating vaccination can be enhanced, and obstacles to vaccination may be appropriately addressed.

2.2. Objectives

1. To determine the immunisation coverage rates of children age 12- 23 months living in the Western Cape Province for at least 6 months
2. To determine the immunisation coverage rates of children age 12- 23 months in the six Health Districts of the Western Cape Province (Table 3 below)
3. To compare immunisation coverage rates in the six Health Districts to identify Districts with low coverage
4. To compare immunisation coverage rates across social class, race and geographical location in order to assess equity of routine vaccination services
5. To determine the prevalence of incomplete vaccinations amongst children aged 12-23 months
6. To determine the prevalence of late vaccinations in children aged 12-23 months
7. To identify factors affecting routine vaccination rates (as perceived by caregivers)

Health Districts of the Western Cape
Cape Metropole (Metro)
Boland
Overberg
West Coast
Eden
Central Karoo

Table 3. The 6 Health Districts of the Western Cape

3. Methodology

3.1. Definition of Terms

EPI-SA: Expanded Programme for Immunisation in South Africa

Vaccination Status: the degree or level of vaccination of a child at a point in time

Fully vaccinated: Children, up to one year of age, who have received all immunisations as per EPI-SA schedule excluding the hepatitis and haemophilus influenza vaccines.

Partially vaccinated: children in the study who have received a portion but not the full intended degree of vaccinations according to their age, in terms of number of vaccinations given as stipulated in EPI-SA norms

Timely immunisation: a given vaccination administered on the scheduled date

Late immunisation: a specified vaccination that is given after the scheduled date as required by EPI-SA standards

Missed vaccination: vaccination that according to EPI-SA guidelines that should have been received by the child, but was omitted for any reason

Mopping -up: the administration of vaccines house-to house to all under-fives regardless of immunisation status

Road to Health card: a card given to the child caregiver by health workers who document vaccinations on this card

Immunisation Schedule:

- Birth to six weeks : OPV0, BCG
- Six weeks: DPT1, OPV1, Hib, HepB
- 10 weeks: DPT2, OPV2, Hib, HepB
- 14 weeks: DPT3, OPV3, Hib, HepB
- 9 months: Measles
- 18 months: DPT4, OPV4, Measles

DPT= Diphtheria, Pertussis and Tetanus vaccine

OPV= Oral Polio Vaccine

BCG= Bacille Calmette-Guérin

Note: this study does not evaluate the coverage of Haemophilus Influenza (Hib) or Hepatitis B (HepB) vaccines

Immunisation coverage rate: the percentage of the at risk population (all children between 12-23 months during the study period) that have received full immunisation as per the EPI-SA norms and standards *for children up to one year of age* (excluding the Hepatitis B and Haemophilus Influenza vaccines).

3.2. Study Design

The study utilised a descriptive cross-sectional design since the main outcomes of interest were prevalence figures. This design gives a 'snapshot' view of immunisation coverage rates in the Districts of the Western Cape Province and is efficient in terms of time and resources. An analytic component was introduced by evaluating possible associations between the primary response variable (vaccination status) and a range of explanatory variables.

3.3. Study Population and sample size

The study population was all children aged 12- 23 months living in the Western Cape Province *for at least six months* prior to the interview.

The sample size for each of the six *health districts* was as follows:

District	Sample size
Cape Metropole	642
Boland	630
Overberg	596
West Coast	610
Eden	622
Central Karoo	524
WESTERN CAPE PROVINCE	3624

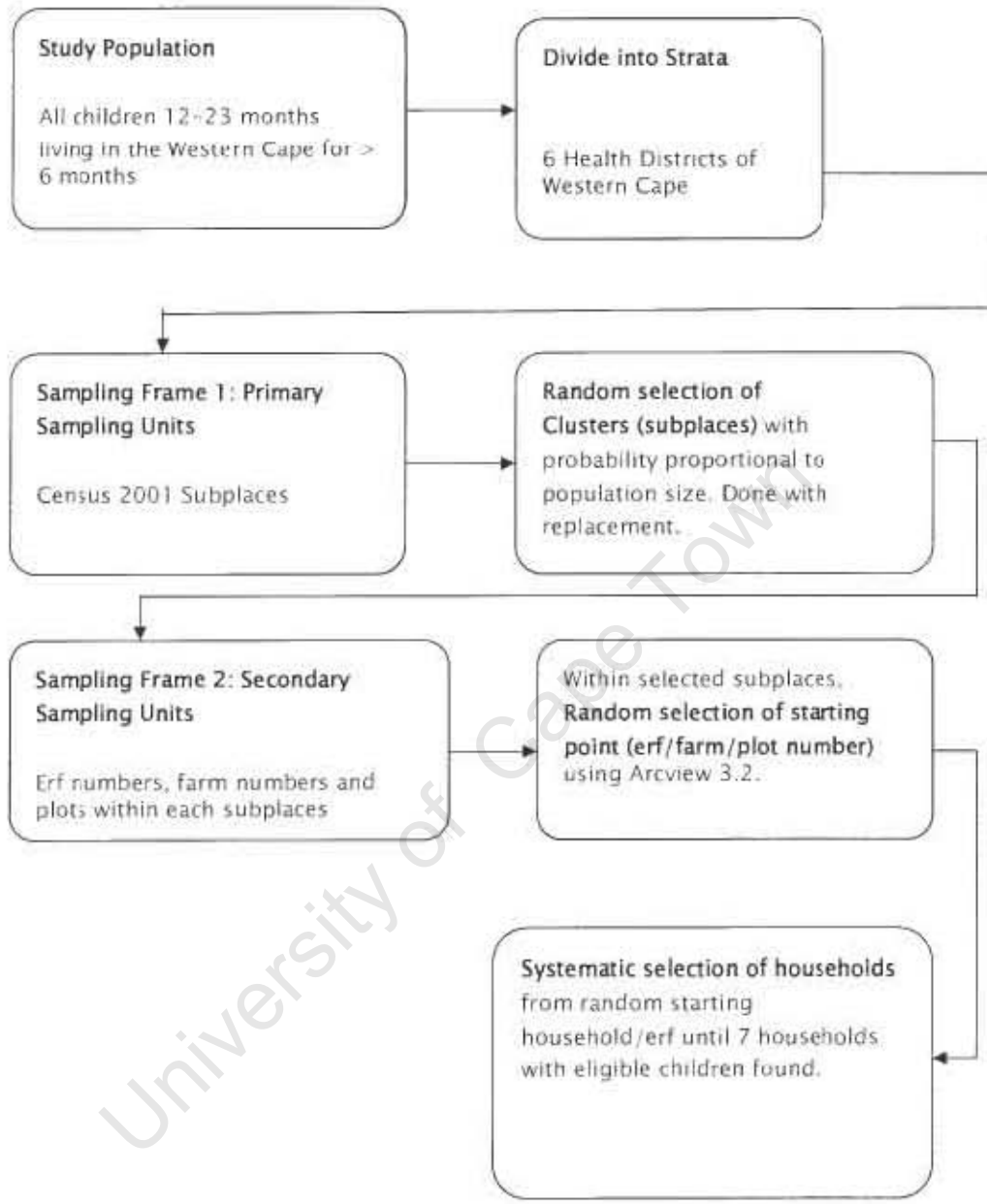
Table 4: Sample size by district

Note: These sample sizes were calculated using an expected prevalence of 70% full immunisation coverage (based on the 2003 DHIS estimate as above) , the Census 2001 population estimates adjusted by the growth factor as used by Statistics South Africa, and with the aim of obtaining point estimates with a +/- 5% confidence interval for each district.

3.4. Sampling

The sampling strategy was an adaptation of the World Health Organisation's '30 by 7' cluster survey technique for immunisation coverage surveys, whereby areas are divided into at least 30 clusters and seven children in each cluster are consecutively selected from a random starting point. A multistage sampling technique similar to this sampling strategy was utilised for each of the 6 Health Districts in the Western Cape Province as summarised in Figure 1 below.

Figure 1: *Sampling Strategy*



For *each district* the sample frame for clusters was a list of Census 2001 subplaces[1] with their corresponding population (of 12-23 month old children). Subplaces from each district were randomly sampled, with the probability of selection proportional to the size of the 12-23 month old population in each subplace (see Appendix 7 for a list of selected subplaces). This was done with replacement.

Within each subplace, the sample frame used was a geographical database of erfs, farms and vacant plots. Erfs, farms or plots were randomly selected as starting points using Arcview 3.2 Random Selection extension, which threw darts randomly within each subplace. The number of darts thrown in each sub-place was equal to the number of times a sub-place had been selected. From each randomly selected starting point, households were systematically selected until 7 households with eligible children were identified.

One child per household was selected, and the primary caregiver interviewed. If there was more than one eligible child at a selected household, the interviewer would allocate numbers to each eligible child in the household and use a dice to select the child on whom information would be obtained.

Households where parents were not at home were visited 3 times in order to obtain an interview, thereafter they were recorded as non-responders.

3.5. Measurement Tools

The measurement tools of this study were the *Road-to Health* card (where available) and a questionnaire. All selected caregivers were interviewed regardless of whether or not they were in possession of a Road to Health card.

3.5.1. Road to Health Card (RTHC)

The interviewer examined the Road to Health card for date of birth, and vaccination dates of the selected children, which were entered on the questionnaire.

3.5.2. Questionnaire

3.5.2.1. Content of the Questionnaire

The questionnaire collected demographic data and information on vaccination status (full/partial/timely/late immunisation as defined in definition of terms above). Where the Road to Health card was not available, the data was obtained by caregiver recall, which is analysed separately in the results. The questionnaire also collected data on the reasons for missed vaccinations.

The questionnaire was compiled in English and then translated into Afrikaans and isiXhosa and back translated into English. Fieldworkers were paired according to language proficiency such that the interview could be conducted in any of the 3 languages mentioned above at any given household; the interviews were conducted in the first language of the respondent where they spoke English, isiXhosa or Afrikaans.

3.5.2.2. Development of the Questionnaire

The draft questionnaire was informed by a review of local and international literature and includes questions from the South African Demographic and Health Survey, questions used on immunisations in other developing country settings and questions from the training manual for EPI coverage surveys by the World Health Organisation[2]. To ensure local applicability, a series of 8 focus groups were conducted in rural and urban areas of the Western Cape where participants were asked their opinions on routine vaccinations (Interview guide in Appendix 1). These groups were conducted in isiXhosa, English and Afrikaans, were translated, transcribed and analysed by a multidisciplinary team, and were utilised to amend the draft questionnaire.

Fieldworkers then piloted the amended questionnaire and all final changes were made to the English, Afrikaans and isiXhosa questionnaires. The final amendments to the isiXhosa questionnaire were not back translated due to time constraints, but

were scrutinised for differences with the English version of the amendments by fieldworkers and corrected.

3.5.3. Validity and Reliability of the study tools

i) Face Validity

The measurement tools have face validity, as one was a clinic card where health workers enter information, and most of the immunisation questions have been taken from field-tested questionnaires (see Section 3.5.2.2. above). We may imagine that determining vaccination status by maternal recall is likely to give an overestimation of immunisation coverage, but studies[3] have shown that where maternal recall is inconsistent with the card, it is more likely to result in an *underestimation* (in other words, mother's are more likely to under-report vaccinations than over-report them), and overall mothers report vaccination status correctly 83-93% of the time[4]. Reasons for and against vaccinating were categorised according to pre-defined categories developed from pre-survey focus groups.

ii) Construct Validity

The questionnaire and Road to Health card assessment measured all the possible immunisation status's possible, namely full/partial immunisation, late/timely immunisation and never immunised. In addition it sought to categorise reasons for sub-optimal vaccination status, the categories for which were exhaustive (to include 'other').

iii) Criterion Validity

The majority of studies assessing vaccination status consider documentation on the Road to Health card to be the gold standard, and many disregard maternal recall of vaccination status in the belief that this is likely to be inaccurate[4]. Using Road to

Health cards alone is likely to significantly under-represent immunisation coverage rates[3]. Several studies have reported that consistency between maternal recall and card documentation is in the order of 83-93% (95% confidence)[5]. The most accurate method of assessing vaccination status is to incorporate both Road to Health cards and maternal recall. All sections of the questionnaire consist of adaptations of field-tested questions that have been used previously in South Africa.

A sub-sample of the study sample was randomly selected for a reliability study, where participants (n=200) were re-interviewed by a different fieldworker using a shortened version of the questionnaire.

3.6 Pilot Study

A pilot study was conducted in both urban and rural areas with locations selected from clusters remaining *after* selection for the main study. This was done in 12 subplaces in the Cape Metropolitan and West Coast Districts. The pilot study tested the logistics of the study as well as the clarity of the questionnaire. The pilot study was successful in refining the questionnaire, however was of limited use in establishing the time taken to locate 7 eligible households as the majority of subplaces not selected by the formal study had extremely small populations of 12-23 month old children, which made time-estimation extremely difficult. Lessons learned from the pilot study were that we had to change data collection hours from office hours to 11am-7pm and include Saturday mornings so that we could ensure collecting information from working parents. On-site communication methods were also established as difficulties in co-ordinating fieldworker pairs in different areas became apparent.

3.7. Data Collection

3.7.1 Site Preparation

584 starting points were randomly selected as described in the sampling methods section above. A map relevant to the study was compiled and printed from Arcview 3.2. for each subplace. The points were represented by erf numbers, farm numbers or as plots on maps.

A team of two co-ordinators, a fieldworker and the Project manager spent 3 months driving to each selected subplace and obtaining the physical addresses of the erf numbers from relevant municipalities. The household would then be located in the subplace and directions to it written on the back of the subplace map. This was seen as essential as many informal settlements and farm areas had no street names, and locating the selected starting point often took several hours.

'Vacant plots' on the map were important to include when selected as starting points as they were very often informal settlements; the team utilised the subplace map and landmarks to locate these plots of land.

Farms were extremely difficult to locate, as municipalities do not keep physical addresses for farms. Several methods were attempted to try and find selected farms, but ultimately TIFF images were obtained from the Department Of Environment and Development Planning: the random starting points were overlaid on these images, and the farm closest to the point was selected.

3.7.2. Training

40 fieldworkers were trained to perform fieldwork for the study. Training consisted of three components, a theoretical background to the study, sampling techniques and research methods, and interview and fieldwork techniques. The theoretical component comprised training on the immunisation schedule, the mechanism of

action of vaccines, side effects and contra-indications of routine childhood vaccines.

Practical exercises on sampling in the field were done, and the principles of selection bias explained. Role-plays were utilised to practice and clarify the questionnaire and develop interview techniques. Potential difficulties in the field were brainstormed and role-played including dealing with dogs, racism, domestic violence, conflict management and so forth.

All trainees were provided with a comprehensive training manual, which included a detailed guide to the completion of the questionnaires.

3.7.3. Fieldwork

The staff consisted of 3 teams each with a co-ordinator and 10 fieldworkers. At the beginning of each week the co-ordinator of each team was given a file with their maps for the week and a list of subplaces with the corresponding number of outstanding interviews. The co-ordinators ensured that each pair of fieldworkers began at their allocated starting point and selected every second household along a fixed route drawn on the maps.

The fieldworkers would establish eligibility of caregivers (those with a child between the ages of 12-23months living in the Western cape for longer than 6 months) and then interview eligible respondents who gave written consent to participation.

Several subplaces required revisits due to small numbers of eligible children, floods, gang violence or widespread alcohol intoxication on a particular day. There were significant problems in Knysna and its surrounding townships as a bizarre rumour spread in the community that we were impostors injecting children with AIDS at gunpoint. After addressing this issue through community meetings and the local media, we managed to obtain a response rate greater than 80%.

Fieldworkers submitted all completed questionnaires and a daily summary sheet to their co-ordinator at the end of each workday. Co-ordinators in turn submitted questionnaires and a weekly summary sheet each week to the Project Manager.

3.7.4. Quality Control

Adherence to the sampling strategy was enhanced by fieldworkers being paired so that each was able to assist the other in counting the appropriate houses. Each group of 10 fieldworkers were managed by a co-ordinator who would check the route followed by fieldworkers, and correct any errors made in sampling. In addition, the addresses on the questionnaire often indicated how fieldworkers were sampling in the field.

The quality of interviews was assessed by having the co-ordinators accompany fieldworkers at random in the field. Correct completion of the questionnaires was checked by fieldworkers' corresponding partner, the co-ordinators and the Project Manager with faulty recordings returned to fieldworkers for correction or re-interview. The phone numbers of all study participants were collected on the questionnaires and respondents were telephoned at random to enquire about the quality of the interview. A reliability study was also conducted whereby a sub-sample of the sample (n=200) was re-interviewed. The results of this study are discussed below.

3.8. Data Management

Correct completion of questionnaires was checked daily by the three team leaders and weekly by the Project Manager during the data collection phase. In preparation for data analysis, responses to every variable were coded on the questionnaires by the interviewers (fieldworkers). Batches of questionnaires were submitted at weekly intervals to a data capturer; the data was double entered into Epi Info 6, which was set up to detect values outside the acceptable range. The two entries were merged

and corrected until unity was achieved. Entered questionnaires were filed in numerical order according to cluster number. At the completion of the data entry the data set was checked for plausibility, errors, missing values and outliers - data queries were resolved where possible by consulting the original questionnaire and interviewer. Where there was persistence of uncertainty or contradictory data, the values were entered as "missing".

3.9. Data Analysis

To take account of the sampling strategy, data was analysed using the survey commands on Stata8 Statistical package, with clusters as the primary sampling units. As the sampling was intended to provide both district and provincial estimates, two sets of weighting were used. Firstly, data was weighted such that a total of seven observations from each cluster were represented in the analysis of *districts* (pweight) resulting in a population representative of the particular district, and secondly, observations within districts were weighted to be representative of the *provincial* population of children aged 12-23 months (Dweight). As such, pweights were used to calculate prevalences within districts, and Dweights were used to calculate provincial prevalences. The primary response variable was vaccination status (fully vaccinated=1, not fully vaccinated=0) at 9 and 18 months, and then an ordinal response variable was defined as the *number* of vaccines received in total (0-12 vaccines).

Summary statistics involved using the Shapiro-wilk test to determine the nature of the distribution of continuous variables. The appropriate summary measures were then calculated (means, standard deviations and confidence intervals for normally distributed variables, and medians and inter-quartile ranges for non-parametric variables). The majority of variables were categorical and as such proportions were calculated with corresponding confidence intervals. Differences in the proportions of fully vaccinated children between districts were calculated by regressing the

outcome against dummy variables for the districts. These differences were adjusted for possible confounders in the final logistic regression model described below.

Data exploration of explanatory variables consisted of using logistic regression to regress the outcome against individual explanatory variables, which yielded unadjusted odds ratios between the outcome and explanatory variables. Model building was performed using regression analysis to determine the impact of individual variables without the effects of confounding. Both multiple logistic and ordinal regression were used to evaluate possible differences in the determinants of vaccination status overall and the *number* of vaccines received; this would be particularly important for children found to be partially immunised for whom we would wish to determine what factors predict differences in the number of vaccines received . Model building was performed as follows: each hypothesised exposure variable (approximately 45 variables) was regressed against the outcome (vaccination status); those variables found to be statistically significantly associated with the outcome were ranked according to the p-value of the univariate association. Each of these variables was added to a multivariate model according to their ranking (variables with the smallest p-vales being added first). Due to the large number of variables found not to be significant, only those variables found to be significant in the multivariate models are shown in this analysis.

As the aim of the *model* was to identify the nature of associations between explanatory factors and the outcome, rather than prevalences, *pweights* were used for the regression part of the analysis. A comparison of the effects of different weightings on the models is presented in the results.

References

[1] Statistics South Africa. Census 2001. Cape Town: Statistics South Africa; 2001.

[2] World Health Organisation. The EPI coverage survey. Training for mid-level managers. World Health Organisation 1991.WHO/EPI/MLM/91.10.

[3] Van Turrennout C, Vandelanotte J, Van den Akker M, Depoorter A. A mass campaign too often? Results of a vaccination coverage survey in the Dikgale-Soekmekaar district. South African Medical; Journal 2003. 93(1): 65-68.

[4] Langsten R, Hill K. The accuracy of mother's reports of child vaccination: the evidence from rural Egypt. Social Science and Medicine. 1998; 46: 1205- 1212.

[5] Aaby P, Martins C, Carlitos B, Lisse I. Assessing measles immunisation coverage by maternal recall in Guinea Buiseeau. Lancet 1998; 352:1229

4. Ethics and Stakeholders

4.1. Ethics

The study was conducted in accordance with the Declaration of Helsinki[1]. The participants in this study included eligible children (as defined above) and their guardians. Every precaution was taken to safeguard the privacy of the participants. The confidentiality of participants' information was maintained throughout the study, and the participants will not be identified by name in this or other reports. Precautions were taken to minimize the psychological effects of the study on participants by emphasising the right to refuse participation, the right not to answer specific questions, and the right to withdraw from the study at any time.

When approaching potential participants, the interviewers identified themselves and their affiliation. Each potential subject was adequately informed of the aims, methods, sources of funding and benefits and risks of the study (as outlined below). If there was an eligible child in the household, and the guardian was mentally competent and willing to participate in the study, she/he was asked to sign the consent form (Appendix 2) indicating their voluntary and informed participation in the study. Those who signed the informed consent form were interviewed in a quiet/ private room where possible. Participants were not reimbursed.

The study was directly beneficial to children in the study with missed vaccinations; guardians were advised to attend the nearest clinic, and given a pre-printed letter stating the need for vaccination (Appendix 4). For those who were fully vaccinated, the study may serve as a reminder to parents to take other children in the household for vaccination, or to ensure they take their child for the next vaccination due. Furthermore, any improvements to health services made as a result of the

study will indirectly benefit the participants and members of the community at large. In this regard, the Child and Maternal Health sub-directorate of the Western Cape has committed itself to addressing vaccination services in low-coverage areas identified by the study. Guardians may benefit from the improved health of their children by the above means.

Understanding the reasons for missed vaccinations will assist in the planning and adaptation of current vaccination services.

Ethical approval for the study was obtained from the University of Cape Town Ethics Committee before the study was commenced.

4.2. Stakeholders

Three groups of stakeholders were identified with regards to this project, as outlined in Table 5 below. Consultation with all the relevant people in the field of application (both subjects and stakeholders) was considered crucial in advance of the project. Initially we had approached clinic staff ourselves (in person or telephonically) but found this impractical; their seemed to be a lack of understanding that we were informing local staff rather than asking their permission, and as such calls became lengthy and drawn out. It was also not feasible to visit every clinic in the Province during site preparation due to time and monetary constraints. The Regional Directors of Health were informed about the study in November 2004 and were asked to relay the message to the primary health care level. To improve buy-in from clinics it was initially planned to utilise community health workers in the survey, but this had to be abandoned due to the lack of community health workers across the Province. Once the teams began fieldwork, it was apparent that few health service providers had indeed been informed through regional and municipal channels.

It was hoped that the health service providers would inform Communities and in addition, community announcements were made on all the major radio stations in

the Province; information was given in English, Afrikaans and isiXhosa. As many people as possible were informed during site preparation, but there were severe time and financial constraints to this process also. Again, experience from the field indicated poor efficacy of these means of communication and most communities had to be informed of the study on arrival of fieldworkers, which was less than ideal.

Table 5: Stakeholders

COMMUNITY	HEALTH SERVICES	INTEREST GROUPS
Community Leaders	Child Health Sub-directorate (Provincial level)	Academic Research community
Community Members	Regional Health Managers	
	Regional EPI directors	
	Community Health Care Centres	

The results will be distributed to health service providers by distribution of this report, and personal feedback and presentations will be given to all four health regions.

Communities should be informed of the study results through local print and radio media.

References

[1] World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human subjects. Journal of Postgraduate Medicine 2002; 48:206-8.

5. Results

5.1. Demographics of the study sample

The total number of caregivers interviewed across the Province was 3705, with a 96% response rate. 96% of caregivers interviewed were female, with a median age of 29 years (IQR: 25-36). The median age of children on whom information was obtained was 17 months (IQR: 14-20). Other demographic variables are summarised in Table 5 below.

Demographics of Caregivers		%	95% CI
Language	Afrikaans	58.3%	(53-64)
	IsiXhosa	26.8%	(21-33)
	English	14%	(10-19)
	Other	1%	(0.5-2)
Population group*	Black	22.8%	(18-28)
	Coloured	56%	(51-61)
	White	6.3%	(4-10)
	Asian/Indian	0.4%	(0.2-1)
	African*	4%	(2.4-5)
	Other	10.9%	(9-13)
Employment status	Unemployed	65.5%	(62-68)
	Employed	34.5%	(32-38)
Monthly income	<R200	3.1%	(2-4)
	R200-R500	7%	(6-8)
	R501-1000	20%	(17-22)
	R1001-R1500	12.8%	(11-15)
	R1500-R2000	10%	(8-12)
	R2001-R3000	10.6%	(9-12)
	>R3000	19.2%	(16-23)
	Don't know	17.3%	(15-21)
Relationship to child	Mother	80.2%	(78-82)
	Grandmother	10.9%	(9-13)
	Aunt	3.4%	(3-4)
	Father	2.4%	(2-3)
	Sister	0.7%	(0.4-1.3)
	Other	2.6%	(2-4)
Education	Primary	19.6%	(17-22)
	Secondary	57.4%	(54-61)
	Tertiary	23%	(20-27)
Marital Status	Single	50.6%	(47-54)
	Married	43.7%	(41-47)
	Divorced/separated	3.2%	(2-4)
	Widowed	2.5%	(2-3)
Location type	Urban	89.4%	(86-92)
	Rural	10.6%	(8-14)

Table 5. Demographic characteristics of caregivers of children aged 12-23 months in the Western Cape

* Population group categorisation was a self-categorisation where respondents were recorded as the race group with which they identify themselves; 'African' was a common response to this question in the pilot study, and was included as its' own category as a result of its frequency.

5.2. Immunisation coverage Results by Group

The immunisation coverage rates were first considered according to three groupings; coverage of vaccinations according to those due by 14 weeks, 9 months and 18 months old. Thereafter immunisation coverage was analysed according to each specific vaccine. The grouping allows for comparison of drop out rates between the first set and last set of vaccinations while the vaccine-specific data highlights which particular vaccines have low coverage rates.

The **key result**, the immunisation coverage of children aged 12-23 months in the Western cape Province and its' 6 Health districts, is the **immunisation coverage rate of vaccinations due at 9 months**, as is the standard in such surveys.

The vaccination rates presented below indicate the percentage of children either fully or partially vaccinated through the routine immunisation programme and ***exclude vaccinations received as a result of immunisation campaigns.*** This section of the analysis refers only to vaccinations received by the date of interview and ***does not report on the timeliness of these vaccinations***; the proportion of timely and late vaccinations per vaccine is presented and discussed below.

5.2.1. Immunisation coverage Rates of vaccines that should have been completed by 14 weeks

In this grouping, fully vaccinated refers to children who have received all 8 vaccinations due by 14 weeks (BCG, OPV0, OPV1, OPV2, OPV3, DPT1, DPT2 and DPT3); children may have received these vaccinations between the ages of 0-23 months. The figures for the Province indicate that between 77- 82% of children in the Province were fully vaccinated. Table 6 indicates the District level coverage, with the confidence intervals for these point estimates. Analysis across district comparing the odds of a child being fully vaccinated, shows that children aged 12-23 months in the Boland were 10-51% (p=0.009) less likely to be fully vaccinated compared to children of the same age-group living in Metro district. No other

districts showed a statistically significant difference when compared to the Metro district.

Immunisation coverage rates of vaccines due by 14 weeks (by card and history)				
	Fully vaccinated (%)	95% CI	Partially vaccinated (%)	95% CI
Western Cape	79.4%	(77-82)	20.6%	(18-23)
Metro	80.7%	(77-84)	19.3%	(16-23)
West Coast	79.5%	(75-83)	20.6%	(17-25)
Boland	73.7%	(69-78)	26.4%	(22-31)
Overberg	75.1%	(69-80)	25%	(20-31)
Eden	81.2%	(77-85)	18.8%	(15-23)
Central Karoo	82.1%	(77-86)	18%	(14-23)

Table 6: Immunisation coverage Rates (%) for all vaccines due by 14 weeks by card and history per Health District. 95% Confidence Intervals (95% CI) shown in parenthesis.

Comparing these results to the immunisation coverage rates of the same vaccinations *by card alone* (i.e. we only regard vaccinations as received if documented on a Road to Health card), we see a slight decline in the coverage rates with the Provincial point estimate ranging between 72- 77% (Table 7).

Immunisation coverage rates of vaccines due by 14 weeks (card only)				
	Fully vaccinated	95% CI	Partially vaccinated	95% CI
Western Cape	74.7%	(72-77)	25.3%	(23-28)
Metro	75.6%	(72-79)	24.4%	(21-29)
West Coast	74.7%	(70-79)	25.3%	(21-30)
Boland	70.5%	(66-75)	29.5%	(25-34)
Overberg	71.6%	(65-77)	28.4%	(23-35)
Eden	75.7%	(71-80)	24.3%	(20-29)
Central Karoo	78.5%	(73-83)	21.5%	(17-27)

Table 7: Immunisation coverage Rates (%) for all vaccines due by 14 weeks by card only per Health District. 95% Confidence Intervals (95% CI) shown in parenthesis.

5.2.2. Immunisation coverage Rates of vaccines that should have been completed by 9 months

The standard in EPI immunisation coverage surveys is to assess the percentage of 12-23 month old children fully vaccinated with all vaccinations due by 9 months in other words, **excluding the vaccinations due at 18 months**. As such, in this group fully vaccinated refers to children who have received all 9 vaccinations due by 9 months (BCG, OPV0, OPV1, OPV2, OPV3, DPT1, DPT2, DPT3 and Measles1). Children may have received these vaccinations between birth and 23 months.

For this group, the immunisation coverage for the Province was between 74% to 79% (Table 8), a decline in coverage rates from those fully vaccinated with 14 weeks' vaccinations. As these are the same individuals, this can be interpreted to mean that the decline is due to a dropout of children, who received all vaccinations except the first measles vaccine. Analysis across district comparing the odds of a child being fully vaccinated, shows that children aged 12-23 months in the Boland were 4-46% (95% CI of unadjusted prevalence odds ratio, p=0.024) less likely to be fully vaccinated compared to children of the same age-group living in Metro district. No other districts showed a statistically significant difference when compared to the Metro district.

Immunisation coverage rates of vaccines due by 9 months (by card and history)				
	Fully vaccinated	95% CI	Partially vaccinated	95% CI
Western Cape	76.8%	(74-79)	23.3%	(21-26)
Metro	77.8%	(74-81)	22.2%	(19-26)
West Coast	77.5%	(73-82)	22.5%	(19-27)
Boland	71.7%	(67-76)	28.3%	(24-33)
Overberg	73.6%	(68-79)	26.4%	(21-32)
Eden	78%	(73-82)	22%	(18-27)
Central Karoo	80%	(75-84)	20%	(16-25)

Table 8: Immunisation coverage Rates (%) for all vaccines due by 9 months by card and history per Health District. 95% Confidence Intervals (95% CI) shown in parenthesis.

Comparing the coverage rates with those calculated using only the Road to Health card as proof of vaccination again shows a predictable decline as indicated in Table 9.

Immunisation coverage rates of vaccines due by 9 months (card only)				
	Fully vaccinated	95% CI	Partially vaccinated	95% CI
Western Cape	72.1%	(69-75)	27.9%	(25-31)
Metro	72.8%	(69-76)	27.2%	(24-31)
West Coast	72.8%	(68-77)	27.2%	(23-32)
Boland	68.5%	(64-73)	31.5%	(27-36)
Overberg	70.1%	(63-76)	29.9%	(24-37)
Eden	72.7%	(67-77)	27.3%	(23-32)
Central Karoo	76.4%	(71-81)	23.6%	(19-29)

Table 9: Immunisation coverage Rates (%) for all vaccines due by 9 months by card only per Health District. 95% Confidence Intervals (95% CI) shown in parenthesis.

5.2.3. Immunisation coverage Rates of vaccines that should have been completed by 18 months

This section considers the immunisation coverage of children aged 18-23 months who have received all vaccinations due by 18 months. As such, fully vaccinated here refers to children who have received all 12 vaccinations due by 18 months (BCG, OPV0, OPV1, OPV2, OPV3, OPV4, DPT1, DPT2, DPT3, DPT4, Measles1 and Measles2). Children may have received these vaccinations between birth and 23 months.

For this group, there was a marked decline from those fully vaccinated with 9 months' vaccinations, with Provincial coverage rates dropping to between 48-56 % (Table 10). This can be interpreted to evidence a further dropout of children, who received all vaccinations at 9 months but missed the vaccinations due at 18 months (Measles 2, DPT4 and OP4). Analysis across the 6 Health Districts shows no statistically significant differences between districts in this group.

Immunisation coverage rates of vaccines due by 18 months (by card and history)				
	Fully vaccinated	95% CI	Partially vaccinated	95% CI
Western Cape	52.3%	(48-56)	47.7%	(44-52)
Metro	53.3%	(47-59)	46.7%	(41-53)
West Coast	52.9%	(47-59)	47.1%	(41-53)
Boland	48.3%	(42-54)	51.7%	(46-56)
Overberg	48.5%	(42-55)	51.5%	(45-58)
Eden	52.4%	(46-59)	47.6%	(41-54)
Central Karoo	54.9%	(49-61)	45.1%	(39-51)

Table 10: Immunisation coverage Rates (%) for all vaccines due by 18 months by card & history per Health District. 95% Confidence Intervals (95% CI) shown in parentheses.

Table 11 below indicates slightly lower coverage results if we consider coverage by card alone, with Provincial rates from 45 to 53%.

Immunisation coverage rates of vaccines due by 18 months (card only)				
	Fully vaccinated	95% CI	Partially vaccinated	95% CI
Western Cape	49.2%	(45-53)	50.8%	(47-55)
Metro	49.2%	(44-55)	50.8%	(45-57)
West Coast	50.4%	(45-56)	49.6%	(44-55)
Boland	48.4%	(42-55)	51.6%	(45-58)
Overberg	49.5%	(43-56)	50.5%	(44-57)
Eden	48.9%	(42-55)	51.1%	(45-58)
Central Karoo	54.5%	(48-61)	45.5%	(39-52)

Table 11: Immunisation coverage Rates (%) for all vaccines due by 18 months by card only per Health District. 95% Confidence Intervals (95% CI) shown in parentheses.

5.3. Immunisation coverage Results by Vaccine

Here the analysis was concerned with the immunisation coverage rates of each of the 12 routine vaccinations administered by the routine immunisation programme; once again, those vaccinations given at immunisation campaigns were not included and timeliness of the vaccine was not considered.

Immunisation coverage rates of the routine vaccinations in the Western Cape Province											
BCG	OPV0	OPV1	OPV2	OPV3	OPV4	DPT1	DPT2	DPT3	DPT4	Measles 1	Measles2
99% (99-99.5)	99.2% (98-100)	94.4% (93-96)	88% (86-90)	**81.3%** (79-84)	**54.4%** (51-58)	97% (96-98)	90.8% (89-92)	**85.2%** (83-87)	**58.7%** (55-62)	92.7% (91-94)	**60%** (56-64)

Table 12. Immunisation coverage by vaccine in the Western Cape Province (by card and history). 95% confidence intervals shown in parentheses, vaccines with inadequate coverage indicated in bold.

As illustrated in Table 12 above, the Western Cape Province has met its' target of 90% immunisation coverage for 7 out of 12 (58.3%) of the routine vaccines analysed. Inadequate coverage was evident for the following 5 vaccines: OPV3 (81.3%), OPV4 (54.4%), DPT3 (85.2%), DPT4 (58.7%) and Measles2 (60%) vaccines.

These trends were similar across five of the Health Districts, with the Boland District having sub-optimal coverage for the OPV3 and DPT2 vaccines in addition to the other five vaccines (Table 13 below).

Immunisation coverage (by card and history) for each vaccine per Health District							
	WC Province	Metro	West Coast	Boland	Overberg	Eden	Central Karoo
BCG	99 (99-99.5)	99 (98-100)	99.5 (99-100)	98.4 (97-99)	99.5 (98-100)	99.4 (98-100)	99.5 (98-100)
OPV0	99.2 (98-100)	99 (98-100)	99.2 (98-100)	99.5 (99-100)	99.6 (99-100)	99.8 (99-100)	99.6 (99-100)
OPV1	94.4 (93-96)	95.2 (93-97)	95.1 (93-97)	91.3 (89-93)	93.3 (90-95)	93.7 (91-96)	95.7 (93-97)
OPV2	88 (86-90)	88.5 (86-91)	88.5 (85-91)	**84.9** (81-88)	87.4 (82-91)	88.6 (85-91)	90.5 (87-93)
OPV3	**81.3** (79-84)	**81.7** (78-85)	**81.5** (77-85)	**79** (75-82)	**78.6** (73-83)	**83.3** (79-87)	**85.3** (81-88)
OPV4	**54.4** (51-58)	**55.4** (50-61)	**53.5** (48-59)	**52** (46-58)	**50.2** (44-57)	**53.5** (47-60)	**56.2** (50-62)
DPT1	97 (96-98)	97.9 (96-98)	98.2 (97-99)	92.4 (90-95)	96.1 (93-98)	97.8 (96-99)	94.8 (91-97)
DPT2	90.8 (89-92)	92 (89-94)	91.6 (89-94)	**85.2** (82-88)	89.9 (86-93)	91 (88-93)	90.4 (87-93)
DPT3	**85.2** (83-87)	**86** (83-89)	**85.8** (83-89)	**79.8** (76-83)	**84.7** (80-89)	87.3 (84-90)	**85.7** (81-89)
DPT4	**58.7** (55-62)	**59.2** (54-65)	**61.3** (55-67)	**54.3** (49-60)	**55.3** (49-62)	**61.4** (55-68)	**60.5** (55-66)
Measles 1	92.7 (91-94)	92.9 (91-95)	94.2 (92-96)	90.8 (88-93)	94.4 (92-96)	93 (91-95)	91.8 (88-94)
Measles2	**60** (56-64)	**60.6** (55-66)	**62.4** (56-68)	**55.9** (50-62)	**55.3** (49-62)	**62.3** (56-68)	**61.4** (56-67)

Table 13. Immunisation coverage rates (%) for each routine vaccine in each district and the Western Cape Province (WC Province). 95% Confidence intervals shown in parentheses. Vaccines with inadequate coverage indicated in bold.

Drop out rates between specific vaccines can be calculated from Table 14; the drop out rate between DPT1 and DPT3 was 11.8%, between BCG and Measles1 was 6.3% and for Measles1 to Measles2 was 32.7%.

A comparison of immunisation coverage rates for each vaccine above with the coverage rates of the Metro District (the reference category) shows five statistically significant differences across districts as indicated in Table 15 below.

Unadjusted prevalence odds ratio of vaccination with DPT and OPV1 vaccines				
	DPT1	DPT2	DPT3	OPV1
Boland				
Prevalence odds ratio	0.25	0.5	0.64	0.53
(95% CI)	(0.13-0.50)	(0.34-0.74)	(0.46-0.9)	(0.33-0.85)
Karoo				
Prevalence odds ratio	0.38			
(95% CI)	(0.17-0.85)			

Table 14. Unadjusted prevalence odds ratio for receiving DPT and OPV1 vaccines (Boland and Karoo compared to Metro district)

These figures mean that the children in Boland were 75%, 50%, 36% and 47% less likely to have received DPT1, DPT2, DPT3 and OPV1 respectively compared to children in Metro (confidence intervals indicated in Table 14). Similarly, children in the Karoo were 62% less likely to have received DPT1 when compared to children in Metro. It is important to note the wide confidence intervals of these point estimates which indicate that we can be 95% certain that these reductions in probability of vaccination in fact range from 10 to 87% in the population.

5.4. Timeliness of Vaccinations

The data was examined to take account of the timeliness of vaccinations; four categories were used to analyse the timeliness of vaccines received. For each vaccine, the relative proportions of children receiving their vaccine on or before the due date, within 28 days after the due date, within 42 days of the due date and after 42 days of the due date were calculated. This analysis allows an appraisal of the trends in timeliness of vaccines given as children get older.

To calculate the timeliness of vaccines received it was necessary to calculate the exact age that the child received the vaccine of interest; as such, these calculations were only performed on vaccines that were documented on a Road-to-Health card. Given this limitation, these results are likely to overestimate the proportion of

timely vaccinations as those without Road to Health cards can be reasonably expected to have less timely vaccinations.

Figures 2 through 4 below illustrate the distribution of timeliness of vaccinations given.

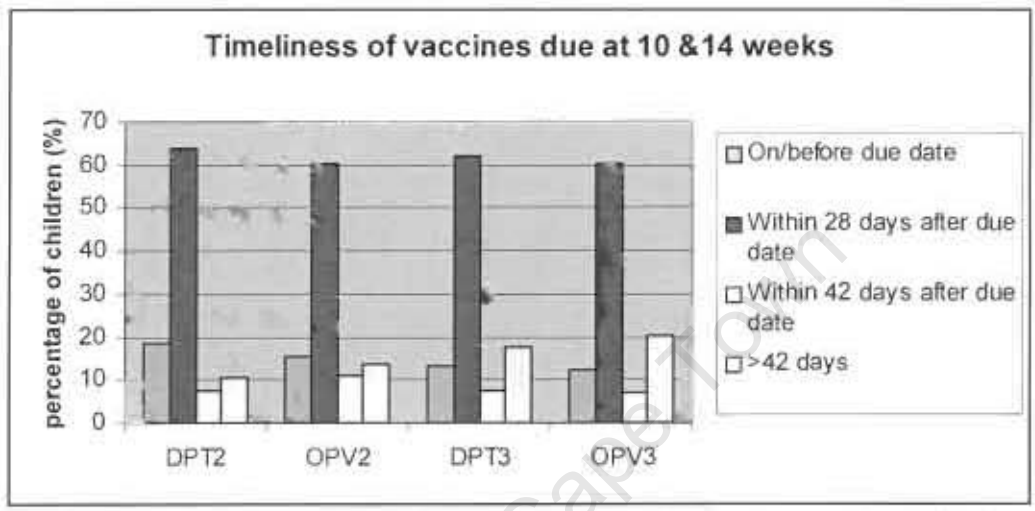


Figure 2. Proportion of children receiving vaccines at 4 specified time categories for DPT2, OPV2, DPT3 and OPV3 vaccines.

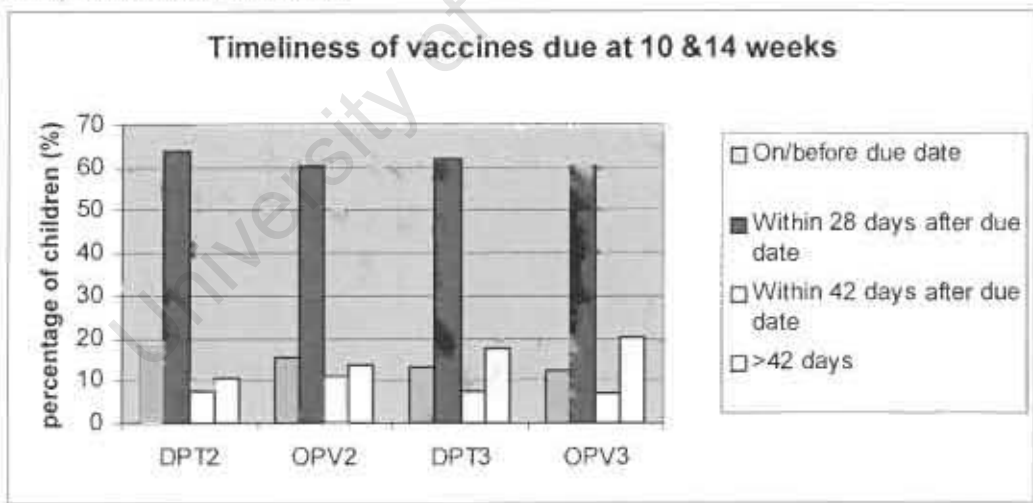


Figure 3 Proportion of children receiving vaccines at 4 specified time categories for DPT2, OPV2, DPT3 and OPV3 vaccines.

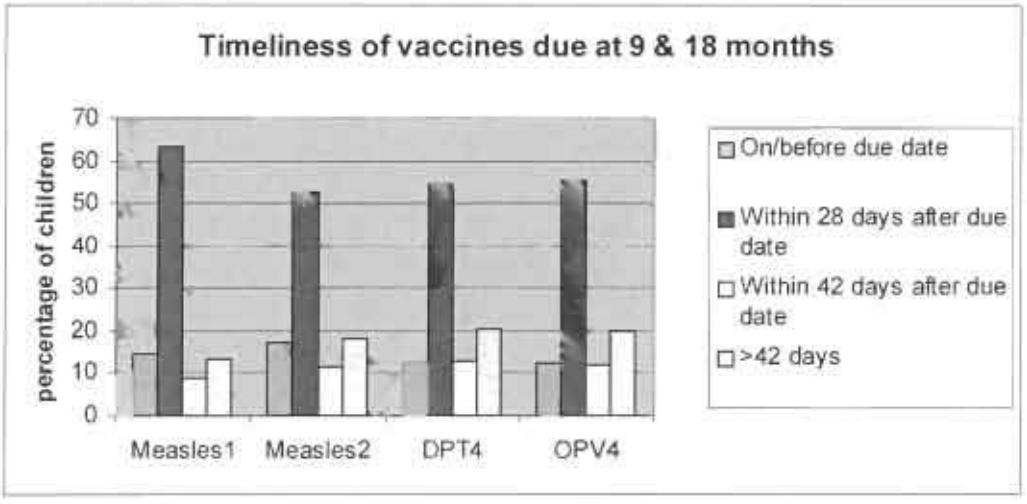


Figure 4 Proportion of children receiving vaccines at 4 specified time categories for Measles vaccines, DPT4 and OPV4.

These results indicate that, with the exception of vaccines given at birth, the minority of children receive their vaccines according to the Immunisation Schedule, with the **majority of children receiving their vaccines within 28 days *after* the due dates**.

Furthermore, the results show a trend in declining rates of timely vaccinations over time (or age) and a corresponding rise in vaccines given within or more than 42 days of the due date. This trend was illustrated best for the DPT vaccines as seen in Figure 5 below.

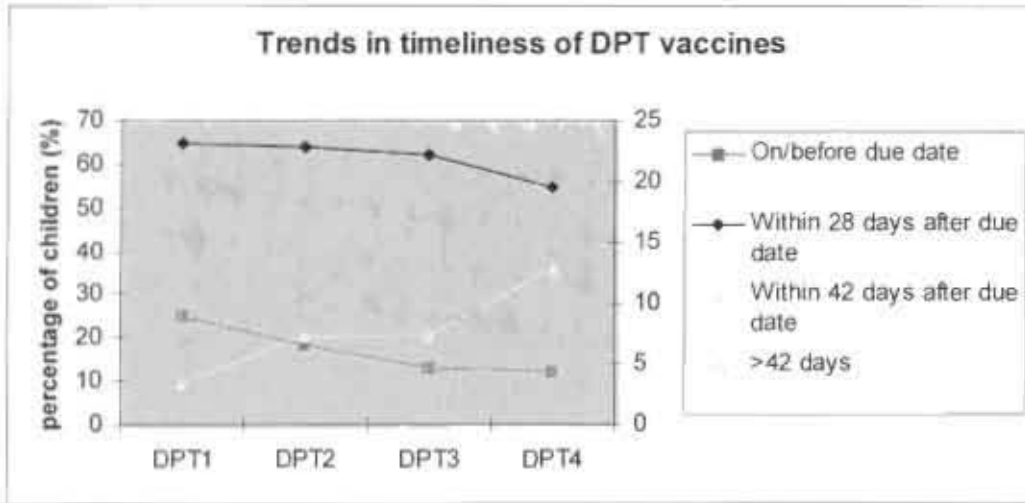


Figure 5. Linear plots of timeliness of all DPT vaccines showing the relative decline in timely vaccinations and relative incline in late vaccinations over time (from DPT1 to DPT4).

Table 15 below indicates the odds of timely vaccinations for each vaccine, using the Metro district as the reference category. These results indicate that for the BCG vaccine, children in the Boland, Eden and Karoo districts were 3 to 5 times as likely to be vaccinated timeously when compared to children in Metro. For the OPV0 vaccine, children living in the Karoo were also more than two times as likely to be vaccinated timeously when compared to children in Metro.

Results

Prevalence odds ratios for having timely vaccinations for each vaccine						
	Metro	West Coast	Boland	Overberg	Eden	Karoo
BCG	1		3.8		3.2	5.5
		ns	(1.4-10.6)	ns	(1.3-7.8)	(1.6-18.8)
			p=0.010		p=0.009	p=0.007
DPT1	1	0.68		0.6		0.63
		(0.46-0.96)	ns	(0.42-0.85)	ns	(0.45-0.89)
		p=0.028		p=0.004		p=0.009
DPT2	1	0.59				0.48
		(0.4-0.87)	ns	ns	ns	(0.32-0.73)
		p=0.008				p=0.001
DPT3	1	0.6				0.54
		(0.39-0.93)	ns	ns	ns	(0.34-0.87)
		p=0.023				p=0.012
DPT4	1	0.4				ns
		(0.17-0.9)	ns	ns	ns	
		p=0.03				
OPV0	1					2.03
		ns	ns	ns	ns	(1.09-3.7)
						p=0.025
OPV1	1			0.65		0.7
		ns	ns	(0.4-0.95)	ns	(0.5-0.9)
				p=0.027		p=0.041
OPV2	1					0.6
		ns	ns	ns	ns	(0.4-0.9)
						p=0.018
OPV3	1					0.6
		ns	ns	ns	ns	(0.4-0.97)
						p=0.04
OPV4	1	0.35				
		(0.15-0.82)	ns	ns	ns	ns
		p=0.016				
Measles1	1	0.25	0.37	0.56	0.35	0.2
		(0.1-0.5)	(0.2-0.6)	(0.3-0.98)	(0.2-0.6)	(0.1-0.4)
		p=0.000	p=0.000	p=0.046	p=0.000	p=0.000
Measles2	1	0.24	0.48		0.51	0.43
		(0.1-0.5)	(0.2-0.94)	ns	(0.3-0.97)	(0.2-0.8)
		p=0.000	p=0.034		p=0.043	p=0.012

Table 15. Prevalence odds of timeous vaccinations for districts compared to Metro (reference category). 95% confidence intervals in parentheses. P value indicated. ns= non-significant difference with Metro.

Children living in the West Coast were between 4 and 60% less likely to have received any DPT vaccine timeously, and were 50-90% less likely to receive either measles vaccine on or before the due date when compared to children in Metro.

Children in the Overberg were between 5-60% less likely to have timely vaccinations for DPT1 and OPV1 relative to children in Metro. In the Karoo, children were less likely to have most vaccines on time than Metro children (see Table 17).

All districts were less likely to have timeous Measles1 vaccinations compared to Metro, with differences typically ranging from 60-90% decreased likelihood of timeous vaccination. This pattern was also seen in the odds of timely vaccinations for Measles2.

5.5. Factors affecting Immunisation coverage

5.5.1. Possession of a Road-to-Health card

Only 79% of the sample (CI: 77-81%) were in possession of a Road-to Health card. The immunisation coverage rate for vaccines due by 9 months for children without a Road to Health card was 20.8% (CI: 15-28%), compared to 76.8% (CI: 74-79%) of children who had a Road to Health card; children with Road to Health cards were 40 times as likely to be vaccinated compared to those without Road to Health cards (Adjusted POR=39.5 95% CI: 30-53).

5.5.2. Perceived usefulness of routine vaccines

Examining parental attitudes to vaccinations, caregivers of children aged 12-23 months were asked about their perceptions of the usefulness of routine vaccines. 98.2% (CI: 97-99%) of caregivers in the Western Cape see routine vaccines as useful.

5.5.3. Caregiver understanding of the purpose of vaccines

To examine caregivers' knowledge and understanding of routine vaccines, participants were asked to explain what they perceive as the purpose of routine vaccines. Table 16 indicates that only 44.3% (40; 48%) of caregivers in the Province understand the purpose of vaccines as protecting against specific diseases, with the majority having erroneous ideas that vaccines protect against all diseases and maintain a child's general health. Caregivers with an incorrect understanding of the purpose of vaccines were 73-87% less likely to vaccinate their children (unadjusted prevalence odds).

What is the purpose of vaccines?		95% CI
Keeps child healthy	29.8%	(27-33)
Protects against all illness	34.7%	(31-39)
Protects against specific illnesses	44.3%	(40-48)
Cures illness	1.2%	(0.6-2)
Don't Know	2.4%	(2-3)
Other	3.8%	(3-5)
Total	100%	

Table 16 Respondents perceptions of the purpose of routine vaccines. 95% confidence intervals in parenthesis.

5.5.4. Knowledge about diseases prevented by routine vaccines

To evaluate the level of more detailed knowledge about routine vaccines, participants were asked to name all the diseases against which routine vaccines offer protection. Six diseases were considered 'correct' responses to the question, namely Measles, Polio, TB, Diphtheria, Pertussis, and Tetanus. Colloquial terms for any of these six diseases were accepted as 'correct' responses. Only 0.2% of caregivers were able to correctly identify all six EPI diseases, with the majority (41%) able to identify only two (most commonly Measles and Polio) as shown in Table 17.

Knowledge about vaccines		
Number of correctly identified diseases prevented by vaccines		(95% CI)
0 correct	7.1%	(6-9)
1 correct	25.4%	(23-28)
2 correct	41%	(39-44)
3 correct	23.2%	(21-26)
4 correct	2.7%	(2-4)
5 correct	0.4%	(0.2-0.9)
6 correct	0.2%	(0-1)
Total	100%	

Table 17. Percentage of respondents (%) able to correctly identify the diseases prevented by routine vaccines. 95% Confidence intervals indicated in parenthesis.

With each additional EPI disease correctly identified by the parent, the relative likelihood of their child being fully vaccinated increases nearly 2 fold (unadjusted POR=1.94 CI: 1.16-3.23).

5.5.5. Perceived risk for EPI diseases

In line with the Health Belief Model[1], caregivers were queried about whether or not they felt their child to be a risk for six of the EPI diseases (Measles, Polio, Tuberculosis, Diphtheria, Pertussis and Tetanus). The results are shown in Table 18, and indicate that the majority of caregivers in the Western Cape felt that their child was at risk for at least some of the EPI diseases. No statistically significant effects of risk perception on the likelihood of being fully vaccinated at 9 months were noted, however caregivers who perceived their children at risk for EPI diseases were 15% (95% CI: 1.05-1.25, adjusted POR) more likely to have their child fully vaccinated for vaccines due at 18 months compared to parents who did not consider their children at risk.

Perceived risk of child getting EPI disease		95% CI
Child at risk for all EPI diseases	31.6%	(28-35)
Child at risk for some EPI diseases	49%	(46-52)
No known risk of any EPI disease	19.4%	(17-22)
Total	100%	

Table 18. Caregiver perceptions of their child's risk for EPI diseases. 95% Confidence Intervals in parentheses.

5.5.6. Caregivers' perceptions of nurses' attitudes

Due to information obtained from the focus groups conducted prior to questionnaire development, the effect of nurses' attitudes on caregivers' behaviour was considered an important variable to measure. 52.9% of caregivers in the Province described nurses as friendly, 35.2% as helpful and 13% as professional (Table 19). A minority of respondents described nurses as rude, unhelpful or unprofessional. When considering the results of this question, it is important to note that there were some serious questions raised about the reliability of the responses to this question (see Section 5.1.2.). The impact of perceived attitude of nurses by caregivers had significant impact on the likelihood of children being fully vaccinated, with positive perceptions (nurses are friendly, helpful or professional) resulting in children being 44% more likely to be fully vaccinated compared to children whose caregivers experienced the nurses more negatively (rude, unprofessional or unhelpful) (adjusted RR=1.52 CI: 1.2- 2.0).

Caregivers' perceptions of nurses' attitudes at vaccination services		95% CI
Friendly	52.9%	(50-56)
Helpful	35.2%	(32-38)
Professional	13%	(11-15)
Unprofessional	4.6%	(3-6)
Rude	8.4%	(7-10)
Unhelpful	3.7%	(2-5)
Some helpful, others not	9.9%	(8-12)
Don't know	1.5%	(1-2)
Other	15.8%	(13-18)

Table 19. Caregivers' perceptions of nurses' attitudes. 95% confidence intervals in parentheses.

5.5.7. Reasons why caregivers vaccinate their children

Caregivers were asked to explain their reasons for taking their child for routine vaccinations, which can be seen in Table 20 below. The commonest reason for having one's child vaccinated was to protect the child from disease (87%) followed by a desire to keep the child healthy (67%) and a sense of parental duty (32.4%). Other common reasons were parents acting on instructions from medical staff (18%) and normative behaviour (18%).

Reasons given for having child vaccinated		95% CI
Protect child against disease	87.8%	(86-89)
Keep child healthy	66.6%	(63-70)
It is my parental duty	32.4%	(29-36)
The nurse/doctor told me to	17.8%	(15-20)
It is normal	17.5%	(15-20)
Other	17%	(14-20)
Seen unvaccinated people become sick	6.1%	(5-7)
I will get other health advice at the clinic	4%	(3-5)
Fear of being shouted at by the nurses	0.6%	(0.3-0.9)

Table 20. Caregiver reasons for having their child vaccinated. 95% confidence intervals in parentheses.

Three of these motivations were found to significantly influence the probability of a child being fully vaccinated (Table 21), with parents motivated by maintaining their child's health, a sense of parental duty and the possibility of getting other health advice at the clinic 22%, 41% and 79% more likely to have their child fully vaccinated respectively.

Unadjusted prevalence odds ratios for the impact of reasons for having vaccines on vaccination status			
	POR	95% CI	p value
To keep my child healthy	1.22	(1.03-1.5)	p= 0.019
It is my duty	1.41	(1.18-1.7)	p=0.000
I will get other health advice	1.79	(1.05-3.1)	p=0.034

Table 21. Univariate prevalence odds ratios for the effect of certain motivators on the probability of a child being fully vaccinated.

5.5.8. Reasons why caregivers miss routine vaccinations

Caregivers whose children had missed certain vaccines, were asked to explain their reasons for this occurrence. In Table 22 the responses have been grouped into 5 categories; the commonest reasons cited were clinic factors (47.1%%), lack of information (26.9%), caregiver being unable to attend the clinic (22.8%) and lack of motivation (13.5%). A breakdown of these categories is presented below.

Reasons given for missing vaccinations		
Clinic factors	47.1%	(45-52)
Lack of information	26.9%	(19-31)
Caregiver unable to go	22.8%	(18-28)
Lack of motivation	13.5%	(8-16)
Other	7.7%	(6-13)

Table 22. Reasons stated by caregivers for missing certain vaccines, grouped into 5 categories. 95% confidence intervals indicated in parentheses.

Comparing differences in these reasons across the 6 health districts , caregivers in the Central Karoo District were more than twice as likely to give clinic factors as a reason (POR=2.29 CI: 1.1- 4.7 p=0.023) compared to those in Metro. There were no other significant differences between health districts.

5.5.8.1. Clinic Factors

Of those respondents stating clinic factors as the reason for missing vaccinations, 34.1% cited missed opportunities, 19.2% were told to come back to the clinic another time , 11% were given incorrect vaccination dates, 9% said the distance of the clinic was too far , 8.7% said immunisation times were inconvenient and 8% experienced vaccines not being available at the clinic (Table 23).

Clinic Factors preventing vaccination		
Missed opportunity	34.1%	(23-46)
Told by nurses to come back another time	19.1%	(12-30)
Wrong return dates given to parents	11.1%	(6-19)
Place of immunisation too far	9%	(5-16)
Time of immunisation too inconvenient	8.7%	(5-16)
Vaccine not available at the clinic	7.7%	(3-18)
Fear of being shouted at by nurses (vaccine already late)	6.7%	(3-13)
Waiting time at the clinic too long	3.6%	(1-10)
Total	100%	

Table 23. Breakdown of clinic factors cited to total 100%. 95% confidence intervals indicated in parentheses.

Table 24 below gives a breakdown of clinic factors by district; caregivers in the Karoo were 7 times more likely to cite distance of the clinic too far (POR=7.2 CI= 2-32, p=0.010) and the vaccine not being available (POR=6.26, CI=1.3-31, p=0.024) compared to those in the other districts. No other statistically significant differences between districts were noted.

Clinic factors cited by caregivers	Eden	Karoo	Metro	Boland	Overberg	West Coast
Missed opportunity	35.4% (18-57)	33.5% (19-52)	42.1% (19-67)	25.8% (12-46)	46.5% (29-65)	40.9% (23-61)
Told by nurses to come back	23% (12-40)	18% (7-38)	24.1% (9-50)	17.9% (7-40)	9.8% (3-27)	22.7% (12-39)
Time of immunisation inconvenient	13.7% (6-27)	5.7% (2-18)	10.8% (3-30)	4.7% (1-19)	6.7% (2-23)	10.2% (4-24)
Place of immunisation too far	10% (3-27)	11.7% (6-21)	5.8% (1-25)	22.1% (10-43)	22.5% (11-40)	7.9% (2-24)
Vaccine not available	7.5% (2-23)	25.2% (13-43)	7.7% (0.9-42)	11.9% (4-29)	6.7% (2-23)	4.9% (1-18)
Fear of nurses	7.5% (2-22)	6% (2-17)	6.1% (1-23)	14.9% (6-33)	3.3% (0.4-23)	5.7% (1-22)
Waiting time too long	2.9% (0.3-2)	0% n/a	3.5% (0.4-25)	2.7% (0.3-19)	4.7% (1-19)	7.6% (2-29)
Total	100%	100%	100%	100%	100%	100%

Table 24. Breakdown of clinic factors by district. 95% Confidence intervals in parentheses.
Note: data on wrong return dates not included here as this information was not collected by district.

Where respondents gave information about specific clinics or incidents, fieldworkers were asked to record this information in a separate report of the cluster visited. As this information was given spontaneously by respondents and recorded at the discretion of fieldworkers, it is inherently biased; fieldworkers would be more likely

to record complaints and as such the information obtained is unrepresentatively negative. Despite this significant limitation, the reports from the field give a good idea of some of the *obstacles* to immunisation reported by respondents, the details of which were not captured by the quantitative questionnaire.

Complaints received in all six of the Health Districts were as follows:

- Parents have little knowledge about importance and purpose of repeat doses
- Parents find Road to Health card non-user friendly; they do not understand the diseases nor the dates and would prefer the language to be targeted at them (names of diseases rather than abbreviations, ages for vaccines rather than dates)
- Many incorrect due dates given
- Clients having to pay for new Road to Health cards
- Inconvenient opening times of clinics (particularly affecting working caregivers)
- Care-givers having to make appointments for vaccines and being turned away if they arrive without an appointment
- Many complaints of racism
- Clinic Road to Health cards not properly filled in; vaccinations filled in the wrong place
- Reports of negative staff attitudes: impatience, mothers reprimanded and humiliated if miss vaccines, staff too busy to attend to mothers properly and answer questions, caregivers being shouted at if they arrive at the clinic 'late', rudeness to and criticism of young mothers, class discrimination, racism, lack of people skills, lack of empathy, threatening mothers and venting of anger on patients saying "go to Mr Mandela and ask for medication because we don't have any".

Please see Appendix 5 for the comprehensive report of comments from the field by district.

5.5.8.2. Lack of information

The main reason cited under lack of information was the caregiver not being in their home area at the time the child's vaccination was due, and being unaware that they could take the child to any clinic (48.6%) (Table 25). This was followed by wrong ideas about contra-indications (e.g. sick children should not be vaccinated) (24.5%), and lack of awareness of the need for a particular vaccine (12.1%).

Lack of information preventing vaccination		95% CI
Unaware that can take child to any clinic for vaccine	48.6%	(36-61)
Wrong ideas about contra-indications	24.5%	(15-37)
Unaware of need to return for next dose	12.1%	(6-23)
Unaware of need for immunisation	9.5%	(5-17)
Place/time of immunisation not known	4.6%	(1-14)
Fear of side-effects	0.7%	(0.1-4)
Total	100%	

Table 25. Breakdown of 'lack of information' reasons cited to total 100%. 95% confidence intervals indicated in parentheses.

5.5.8.3. Caregiver obstacles

This group consisted of two possible reasons as indicated in Table 26 below.

Care-giver unable to attend clinic		95% CI
Primary care-giver too busy with other tasks	73.8%	(60-84)
Family problem, including care-giver illness	26.2%	(16-40)
Total	100%	

Table 26. Breakdown of caregiver obstacles cited to total 100%. 95% confidence intervals indicated in parentheses.

5.5.8.4. Lack of motivation

Of the 9.8% respondents citing lack of motivation as the reason for missing vaccinations, 62.8% said they forgot to take their child for vaccinations, 30% postponed taking the child until another time, and 4.7% did not see the need for the vaccine given that their child was healthy. A minority cited previous bad experiences or negative perceptions of vaccines as a reason for not vaccinating (Table 27).

Lack of motivation		95% CI
For ,ot	62.8%	(44-78)
Vaccine , ost, oned	29.4%	(15-49)
Child is healthy so vaccine unnecessary	4.7%	(1.5-12)
No faith in vaccines	1.4%	(0.1-10)
Previous bad ex, erience with vaccines	1.2%	(0.3-8)
Vaccines are harmful	0.5%	(0-4)
Total	100%	

Table 27. Breakdown of 'lack of motivation' reasons cited to total 100%. 95% confidence intervals indicated in parentheses

5.5. 9. Equity of immunisation coverage

Table 28 below documents the impact of gender, race, social class and location on the probability of a child being fully vaccinated (unadjusted prevalence odds ratios presented). From this analysis racial inequality was evident, with 'black' and 'african' children less likely than 'coloured' children to be fully vaccinated by 40% and 57% respectively. No statistically significant differences were seen due to gender or rural location. In terms of socio-economic status, income had no significant effects, but children of employed caregivers were 20% less likely to be fully vaccinated compared to children of the unemployed, and children of caregivers with a secondary education were 2% more likely to be fully vaccinated compared to children of parents with only a primary education. Tertiary education had no statistically significant effect on vaccination status.

Unadjusted Prevalence odds ratios for the effects of equity variables on vaccination status for vaccines due by 9 months				
		POR	95% CI	p value
Gender	female	1		
	male	1.05	(0.89-1.2)	p=0.61
Race*	coloured	1		
	black	**0.6**	(0.45-0.8)	**p=0.001**
	white	0.87	(0.57-0.14)	p=0.568
	Asian	0.64	(0.1-6)	p=0.862
	african	0.43	(0.2-0.76)	**p=0.004**
Location	urban	1		
	rural	1.17	(0.88-1.57)	p=0.285
Socio-economic status				
Education	Primary school	1		
	Secondary school	**1.02**	(1.005-1.04)	**p=0.011**
	Tertiary	1.12	(0.89-1.4)	p=0.331
Employment	Unemployed	1		
	Employed	**0.8**	(0.68-0.95)	**p=0.009**
Income	< R200	1		
	R200-R500	0.8	(0.57-1.14)	p=0.227
	R500-R1000	1.1	(0.83-1.46)	p=0.293
	R1000-R1500	1.2	(0.91-1.7)	p=0.485
	R1500-R2000	1.3	(0.9-1.7)	p=0.171
	R2000-R3000	1.15	(0.88-1.48)	p=0.177
	>30000	1.3	(0.97-1.8)	p=0.076

Table 28. Unadjusted Prevalence odds ratios (POR) for the probability of a child being fully vaccinated. 95% confidence intervals indicated in parentheses. Statistically significant results indicated in bold. *Race was a self-categorizing variable; respondents categorised themselves with any name they thought appropriate (including African).

The Immunisation coverage Rates for vaccines due by 9 months by race and language are presented in Table 29, which illustrates the differences in immunisation coverage rates across all 6 health districts. Racial differences were most apparent in the Boland and Overberg districts; univariate analysis indicates that black children in the Boland were 63% (CI: 37-78%) less likely than children of

other races to be fully vaccinated (this contrasts with other districts where black children were 25% (CI: 2-42%) less likely to be fully vaccinated compared to children of other races).

Immunisation coverage Rates for vaccines due by 9 months by Race and Language										
	Black	Coloured	White	Asian/Indian	African	Other	Xhosa	Afrikaans	English	Other
Province	73.5% (66-80)	78.2% (75-81)	84.3% (74-91)	72% (27-95)	65.4% (54-75)	75.5% (68-82)	75.2% (69-81)	77.9% (75-80)	76.6% (70-82)	47.8% (20-77)
Metro	75.8% (67-83)	79% (74-83)	86.9% (73-94)	75% (23-97)	64% (49-76)	77.5% (74-81)	77.2% (69-84)	79.5% (74-84)	77.2% (70-83)	47.8% (17-81)
West Coast	84.3% (70-93)	76.2% (71-81)	84.2% (66-94)	n/a n/a	83.3% (43-97)	79% (62-90)	86.5% (78-92)	76.7% (72-81)	77.5% (40-95)	70% (15-96)
Boland	52.3% (40-64)	76.5% (72-80)	69.4% (42-87)	n/a n/a	71.1% (48-87)	62.1% (48-74)	55.4% (43-67)	74.5% (70-78)	54.7% (32-76)	
Overberg	58.8% (49-68)	77.6% (71-83)	89.7% (67-97)	n/a n/a	40.3% (15-72)	75.3% (60-86)	60.8% (49-71)	76.9% (70-82)	63.1% (35-85)	46.8% (35-85)
Eden	78.4% (69-85)	78.7% (73-84)	77.4% (57-90)	n/a n/a	78.7% (47-94)	73.4% (62-82)	76.9% (68-84)	78.6% (73-83)	70% (28-93)	62.6% (30-93)
Karoo	70.4% (58-81)	80.7% (75-85)	77% (47-93)	n/a n/a	n/a n/a	77.4% (61-88)	76.3% (64-85)	80.3% (75-85)		

Table 29. Immunisation coverage rates of vaccines due by 9 months by race, language and district. n/a= not applicable (as these districts have no Asian population)

In an attempt to explain why 'black' children in the Western Cape were less likely than any other race group to be fully vaccinated, prevalence odds ratios of the likelihood of several other variables already shown to be correlated with vaccination status were calculated and are presented in Table 30.

Why 'black' children in the Western Cape may have lower immunisation coverage			
Variable	POR	95%CI	p value
Care giver has a secondary education	1.4	(1.13-1.71)	p=0.001
Purpose of vaccines: protects vs. all diseases	2.86	(2.3-3.6)	p=0.000
Purpose of vaccines: protects vs. specific illness	0.58	(0.45-0.74)	p=0.000
Child at risk for EPI diseases	0.28	(0.22-0.34)	p=0.000
Nurses are professional	0.32	(0.21-0.49)	p=0.000
Nurses are rude	1.97	(1.39-2.79)	p=0.000
Reason missed: unaware of need to return	3.41	(1.23-9.6)	p=0.019

Table 30. Prevalence odds ratios (POR) for the presence of a range of variables associated with vaccination status, such that an POR>1 indicates an increased presence of the variable in black respondents compared to other race groups.

What this analysis indicates is that the observed difference cannot be explained by differences in educational attainment, as black care-givers were 40% more likely to have received a secondary education compared to other race groups. Similarly, the effect of race on vaccination status was not changed by adding socio-economic status to the model (i.e. cannot be accounted for on the basis of class or educational differences).

There were problems in this race group related to knowledge of vaccinations, with a 3-fold increase in misperceptions about the purpose of vaccines (vaccines protect against all major illnesses), a 42% relative decrease in knowledge of the actual purpose of vaccines, and a 72% relative decrease in perceptions of risk for EPI diseases compared to other race groups. In terms of reasons stated for missing vaccinations, black caregivers were more than 3 times as likely to state they were unaware of the need to return for a second/third dose of a vaccine Most disturbingly, black caregivers were 68% less likely to perceive nurses as having a professional attitude, and were 97% more likely to experience nurses as rude compared to caregivers of other races.

5.6. Model building: factors associated with vaccination status and number of vaccines received

Models for the likelihood of being fully vaccinated and for receiving greater numbers of vaccines were calculated for vaccines due by 9 and 18 months. This process was done in order to determine the *independent* effects of a range of factors seen to be influencing vaccination status. Both multiple and ordinal regression were used to evaluate possible differences in the determinants of vaccination status overall and the *number* of vaccines received; this would be particularly important for children found to be partially immunised for whom we would wish to determine what factors predict differences in the number of vaccines

received (frequency distribution of the numbers of vaccines for the 9 and 18 month models shown in Tables 31 & 32 below).

Total no. of 9 months' vaccines received	n	%	95% CI
0	5	0.2	(0-7)
1	9	0.37	(0.15-0.87)
2	26	0.64	(0.37-1.1)
3	49	1.18	(0.75-1.9)
4	156	3.74	(2.9-4.9)
5	80	2.45	(1.2-3.4)
6	178	4.92	(3.9-6.3)
7	97	2.35	(1.7-3.2)
8	272	7.35	(6.2-8.9)
9	2833	76.8	(74.3-78.9)
Total	3705	100	

Table 31: Proportions of number of vaccines received for vaccines due by 9 months (entire sample used)

Total no. of 18 months' vaccines received	n	%	95% CI
0	3	0.21	(0-1.2)
1	5	0.45	(0.1-1.4)
2	18	0.76	(0.4-1.4)
3	20	1.38	(0.7-2.3)
4	78	3.75	(2.6-5.3)
5	31	2.45	(1.5-3.9)
6	73	4.73	(3.3-6.5)
7	32	1.57	(0.9-2.5)
8	94	5.47	(4.2-7.2)
9	363	18.77	(16.2-21.7)
10	36	2.49	(1.5-4)
11	105	5.67	(3.8-7.2)
12	929	52.3	(49.4-56.8)
Total	1787	100	

Table 32: Proportions of number of vaccines received for vaccines due by 18 months (sub-sample of children older than 18 months)

For both 9 and 18 month vaccines, both logistic and ordinal regressions were performed. As such, four models were calculated (Tables 33-36) below. As indicated in the methodology section, due to the large number of variables found

not to be significant, only those variables found to be significant in the multivariate models are shown in this analysis.

Model 1: 9 months' binary model

This model (Table 33) evaluates the determinants of immunisation coverage for vaccines due by 9 months and uses multiple logistic regression with vaccination status as the primary response variable (fully vaccinated=1, not fully vaccinated=0).

Explanatory variable	OR	95% CI	p-value
RTHC	39.5	(20-53)	p=0.000
Positive attitude of nurses	1.52	(1.2-2)	p=0.001
Vaccinated children out of parental duty	1.4	(1.1-1.7)	p=0.005
Race-black	0.79	(0.56-1.1)	p=0.152
Age (months)	1.08	(1.04-1.1)	p=0.000
Knowledge score (percent)	2.16	(1.09-4.3)	p=0.028
Secondary education	1.04	(1.01-1.06)	p=0.005
Vaccinated child to keep child healthy	1.29	(1.04-1.65)	p=0.022
Vaccinated child to get other health advice	2.27	(1.16-4.44)	p=0.017
Boland Overberg	0.81	(0.6-1.1)	p=0.162
Black*BolandOverberg	0.44	(0.25-0.77)	p=0.004

Table 33: Model 1: multiple logistic regression model for vaccination status of vaccines due by 9 months. RTHC=Road to Health Card

Model 2: 9 months' ordinal model

This model (Table 34) evaluates the determinants of the *number* of vaccines (due by 9 months) that the child has received and the proportional odds model for an ordinal outcome (number of vaccines due by 9 months that have been received N= 0-9).

Explanatory variable	OR	95% CI	p value
RTHC	67.5	(42.4-107.5)	p=0.000
Positive attitude of nurses	1.68	(1.34-2.09)	p=0.000
Boland district vs all other districts	0.62	(0.47-0.82)	p=0.001
Knowledge score (percent)	14.4	(5.46-38.2)	p=0.000
Race-black vs other race groups	0.63	(0.49-0.81)	p=0.000
Vaccinated child to get other health advice	2.55	(1.5-4.5)	p=0.001
Age	1.06	(1.04-1.11)	p=0.000
RTHC*knowledge	0.22	(0.06-0.82)	p=0.015

Table 34: Model 2: ordinal regression model for number of vaccines received (of vaccines due by 9 months) RTHC=Road to Health Card

Model 3: 18 months' binary model

This model (Table 35) evaluates the determinants of immunisation coverage for vaccines due by 18 months and uses multiple logistic regression with vaccination status as the primary response variable (fully vaccinated=1, not fully vaccinated=0).

Explanatory variable	OR	95% CI	p value
RTHC	11.28	(5.89-23.60)	p=0.000
Vaccinated children out of parental duty	1.59	(1.18-2.24)	p=0.009
Age (months)	1.31	(1.20-1.44)	p=0.000
Positive attitude of nurses	1.65	(1.14-2.38)	p=0.008
Risk perception: number of diseases child at risk for	1.15	(1.05-1.25)	p=0.002
The purpose of vaccines is to cure illness	0.13	(0.03-0.50)	p=0.003

Table 35: Model 3: multiple logistic regression model for vaccination status of vaccines due by 18 months. RTHC=Road to Health Card

Model 4: 18 months' ordinal model

This model (Table 36) evaluates the determinants of the *number* of vaccines (due by 18 months) that the child has received and the proportional odds model for an ordinal outcome (number of vaccines due by 18 months that have been received N= 0-12).

Explanatory variable	OR	95% CI	p value
RTHC	28.46	(14.48-55.94)	p=0.000
Vaccinated children out of parental duty	1.4	(1.01-1.94)	p=0.044
Age	1.23	(1.11-1.37)	p=0.000
Knowledge score (percent)	3.75	(1.42-9.92)	p=0.008
The purpose of vaccines is to cure illness	0.28	(0.15-0.53)	p=0.000
Positive attitude of nurses	1.56	(1.14-2.14)	p=0.005
Caregiver of the child is the child's sister	0.07	(0.01-0.62)	p=0.035

Table 36: Model 2: ordinal regression model for number of vaccines received (of vaccines due by 18 months) RTHC=Road to Health Card

Rather than describing each model individually, it is more useful to consider the effect of the individual *variables* on the vaccination outcomes across the models. For this purpose, Table 37 and the discussion below summarises the prevalence odds ratios across all four models (only point estimates are mentioned here; please see individual models above for confidence intervals and p-values).

Explanatory variables from all models	Model 1 9 months binary	Model 2 9 Months ordinal	Model 3 18 months binary	Model 4 18 months ordinal
RTHC	39.5		11.28	28.46
RTHC where care_iver has low knowled_e score		67.5		
RTHC where care_iver has hi_h knowled_e score		14.9		
Positive attitude of nurses	1.52	1.68	1.65	1.56
A_e	1.08	1.06	1.31	1.23
Knowled_e score (_ercent)	2.16			3.75
Knowled_e score where care_iver has no RTHC		14.4		
Knowled_e score where care_iver has a RTHC		3.2		
Vaccinated children out of _arental duty	1.4		1.59	1.4
Race-black vs. other race grou_s		0.63		
Bein_ black in the Boland-Overber_ Districts	0.35			
Bein_ black in other Districts	_>0.05			
Vaccinated child to _et other health advice	2.27	2.55		
Boland district vs. all other districts		0.62		
Effect of livin_ in the Boland if care_iver is black	0.36			
Effect of livin_ in the Boland if care_iver is not black	_>0.05			
Secondary education	1.04			
Vaccinated child to keep child healthy	1.29			
Care_iver of the child is the child's sister				0.07
Risk _erce_tion: number of diseases child at risk for			1.15	
The _urpose of vaccines is to cure illness			0.13	0.28

Table 37: Comparison of Models 1-4 comparing logistic and ordinal regression for vaccines due by 9 and 18 months. RTHC=Road to Health Card

In general, it is evident from Table 37 that there were more factors associated with vaccination outcomes at 9 months compared to those at 18 months. This may represent real differences in the factors that determine outcomes at these different ages, however it should also be noted that the sample size for each group was markedly different (n=3705 for 9 month vaccines whereas n=1787 for 18 month vaccines) which may also account for some of the observed differences.

Whether or not a caregiver was in possession of a **Road-to-Health card (RTHC)** was by far the strongest predictor of vaccination status and predicts both ordinal and binary outcomes for vaccines due by 9 and 18 months. It was clear however that having a RTHC was more important a predictor of vaccinations due by 9 months; in terms of the binary models, caregivers with a RTHC were nearly 40 times as likely to

have their child fully vaccinated with the 9 month set of vaccines compared to those caregivers without a RTHC whereas for vaccines due by 18 months, the RTHC only increases the odds of being fully vaccinated 11 fold. In Model 2 (9 months ordinal model), we see an interesting interaction whereby the effect of having a RTHC on the number of vaccines received was much greater for caregivers with a poor knowledge of vaccines; for children of caregivers with a poor knowledge of vaccines, possession of a RTHC increased the odds of receiving more vaccines 68 fold, however children of caregivers with a good knowledge of vaccines were only 15 times more likely to have received more vaccines than children of caregivers without a RTHC.

Another factor found to be a predictor of all outcomes across the 4 Models was **perceived attitude of nurses**. This variable has similar effects on all the outcomes considered with caregivers who experienced nurses' attitudes as positive 52-68% more likely to have fully vaccinated children compared to those who perceived nurses' attitudes as negative.

Age of the child was also a consistent determinant of outcomes in all the models; with each month increase in age, children were 6-23% more likely to receive vaccinations. Age appears to have a stronger effect on vaccination outcomes for 18 months' vaccines with the effects approximately 10-20% higher for this group compared to the 9 month group. This finding is intuitive as the older children were the longer time their caregivers have had to vaccinate them.

Caregiver knowledge of what diseases vaccines protect against was found to be a predictor in all but one of the models[1]. In Models 1 and 4 the relationship was straight-forward with each percentage increase in caregiver knowledge increasing the likelihood of receiving vaccinations by 216% (Model 1) to 375% (Model 4). An interaction between caregiver knowledge and possession of a RTHC was found such

[1] Knowledge score calculated as the percentage of EPI diseases correctly named by caregivers

that the effect of knowledge was greater where caregivers do not have a RTHC (14.4 fold increased likelihood of vaccinations compared to 3.2 fold increase where caregivers do not have a RTHC).

What motivated caregivers to vaccinate their children was also found to impact on vaccinating behaviour with **children whose parents were motivated to vaccinate them out of parental duty** 40-59% more likely to be fully vaccinated or receive more vaccines than those who were motivated by other reasons. The effect of this variable was much the same across the four response variables.

The effect of **race** was only significant for vaccines due by 9 months and differed in the binary (Model 1) and ordinal (Model 2) models. In Model 2, 'black' children were 63% more likely than children of other races to receive fewer vaccines. In Model 1, however, race only influences vaccination status if a child lives in the Boland-Overberg where 'black' children were 65% less likely than children of other races to be fully vaccinated. The effect of race on vaccination status in other districts was not found to be statistically significant.

Caregivers' expectations of obtaining other health advice when getting vaccines was significant in both 9 months' models (Models 1 & 2) but was not statistically significant in the 18 months models. Caregivers who felt they would get other health advice at the clinic when taking their child for vaccines were more than twice (227%-255%) as likely to take their child for vaccinations compared to those caregivers who gave other reasons for taking their child for vaccines.

District of current residence was also a predictor of vaccination outcomes, however significant differences between districts were only found for vaccines due by 9 months and did not influence the 18 month outcomes. For vaccines due by 9 months, **children living in the Boland** were 38% less likely to have received more vaccines than children from other districts. For the binary outcome, however,

district was associated with vaccination status for 'black' children only; 'black' children in the Boland-Overberg were 64% less likely to be fully vaccinated than 'black' children living in other districts.

For vaccinations due by 9 months (Model 1), children whose **parents had a secondary education** were 4% more likely to be fully vaccinated compared to those children whose parents only had a primary school education. This was found in the binary model only and as such was a predictor of overall vaccination status rather than the number of vaccines children receive i.e. for those children not fully immunised it did not predict differences in the number of vaccines received.

In the binary 9 month model (Model 1) only, children whose **parents were motivated to vaccinate them out of a desire to *keep* them healthy** were 29% more likely to be fully vaccinated than those whose parents were motivated to vaccinate their children for other reasons.

Factors associated with the 18 month outcomes only were as follows: children whose **primary caregiver was their sister** were 93% less likely to have received a greater number of vaccines than children whose primary caregiver was not their sister (parents, grandparents, aunts or uncles). Secondly, for each additional **disease caregivers perceive their child to be at risk for**, the likelihood of the child being fully vaccinated increases by 15%. Lastly, where caregivers mistakenly thought that **vaccines cure illness**, they were found to be 72-87% less likely to receive more vaccinations or be fully immunised compared to children of caregivers with a better understanding of the purpose of vaccines.

Please note that **the reasons caregivers' gave for missing vaccines** (question 26) were excluded from all the models as respondents who answered this question constituted a very small sub-sample of the total sample (<9% of the sample) and as such must be modelled for the sub-sample alone . However, due to unforeseen

systematic fieldworker error, this question was not asked of all participants who had missed vaccinations and as such was not representative of the study population. This being the case it was decided not to calculate a Model for this sub-group as was originally intended.

5.6.1. Model checking

As the most important model, Model 1 was checked for its ability to predict vaccination outcomes. Due to the complicated sampling strategy employed, model checking was performed by evaluating the models ability to predict the observed outcomes (1= fully vaccinated, 0= not fully vaccinated). The mean predicted probability of the outcome for outcomes equal to zero was 0.43 (CI: 0.4-0.46), whereas the mean predicted probability of the outcome was 0.87 (CI: 0.86-0.88) for outcomes equal to one; in other words, the model correctly predicted the outcome approximately 87% of the time when the outcome was equal to one (fully vaccinated) whereas if the outcome was zero (not fully vaccinated), the model was only able to predict this correctly in 43% of cases. Table 38 illustrates the spread of predicted probabilities for each outcome option. In conclusion, the model was better at predicting factors affecting children getting vaccinations, rather than factors affecting children not being vaccinated.

Predicted probability of outcome	Outcome=1	Outcome=0
pr<0.15	0.5	17.5
pr= 0.15-0.4	4	44
pr=0.5-0.9	37	22
pr>0.9	58.5	16.5
Total	100	100

Table 38. Proportion of predicted probabilities of disease (pr) in each category of outcome.

5.6.2. Effect of weighting on results

The models were calculated using pweights as described above (weighting for representivity at a *district* rather than *provincial* level). For comparative purposes, Table 39 below shows the prevalence odds ratios of the explanatory variables for Model 1 when no weighting, pweights (district weighting) and Dweights (provincial weighting) were used.

Explanatory variable	POR no weight	95% CI	POR pweight	95% CI	POR Dweight	95% CI
KLIHC	38.7	(30-49)	39.5	(30-53)	51.2	(33-80)
Positive attitude of nurses	1.55	(1.2-2)	1.52	(1.2-2)	1.5	(1.04-2.1)
Vaccinated children out of parental duty	1.4	(1.1-1.7)	1.4	(1.1-1.7)	1.7	(1.2-2.4)
Race-black	0.79	(0.56-1.1)	0.79	(0.56-1.1)	0.69	(0.44-1.07)
Age (months)	1.08	(1.05-1.1)	1.08	(1.04-1.1)	1.07	(1.0[illegible]-1.1)
Knowledge score (percent)	2.26	(1.16-4.4)	2.16	(1.09-4.3)	5.11	(1.7-15.2)
Secondary education	1.27	(1.01-1.6)	1.04	(1.01-1.06)	1.4	(0.89-2.18)
Vaccinated child to keep child healthy	1.22	(0.98-1.5)	1.29	(1.04-1.65)	0.96	(0.68-3.9)
Vaccinated child to get other health advice	2.23	(1.18-4.2)	2.27	(1.16-4.44)	1.5	(0.62-3.9)
Boland Overberg	0.81	(0.6-1.03)	0.81	(0.6-1.1)	0.69	(0.47-1.01)
Black*BolandOverberg	0.44	(0.26-0.76)	0.44	(0.25-0.77)	0.5	(0.23-1.03)

Table 39 Comparative prevalence odds ratios for the explanatory variables in the model using different weightings.

While the point estimates remain mostly the same, there was a clear widening of confidence intervals as we move from no weighting, to subplace (pweight) weighted data and finally to subplace *and* district (Dweight) weighted data. This is unsurprising given the greater degrees of uncertainty associated with the increasingly complex sampling strategies. Some variables were no longer significant in the Dweighted model, which could result from the widened confidence intervals (to include one), or real differences in these factors in the different districts. Metro district has the highest population size, and as such Dweighted data will be more reflective of the interplay of variables here rather than other districts.

5.7. Reliability of the questionnaire

A sub-sample of the study sample was selected for the reliability study, where participants were re-interviewed by a different fieldworker using a shortened version of the questionnaire. Responses were compared by calculating the kappa statistic, which should be greater than 0.5 to ensure adequate reliability. The kappa for vaccination status according to card, ranged between 0.6 to 0.78 depending on the specific vaccine (p=0.000). The kappa statistic for vaccination status according to history was 0.66 to 0.87 for vaccines given up to 3 times (p=0.0000), and was 0.3 to 0.46 for DPT4 and OPV4. In other words, maternal/care-giver recall had good reliability where the vaccine was given less than four times, but had poor reliability where the vaccine was given four times.

References

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6. Conclusions

While the coverage recorded in this survey is a marked improvement from the 68% coverage measured in the Demographic and Health Survey in 1998[1], it still falls significantly short of the 90% EPI-SA target for 2005. Indeed, inadequate immunisation coverage was found across the Province with the lowest immunisation coverage rates in the Boland District. The strength of the estimates presented here are that they are the result of empirical research where percentage coverage is calculated from the vaccination status of specific children, rather than relying on proxy measures of coverage (such as total doses dispensed divided by live births or population numbers). As such the inaccuracy of estimates is grossly diminished.

The majority of children in the Province receive their vaccinations after the due date (only 12-25% receive vaccines on or before due dates), with the exception of vaccines given at birth and increasingly so as children get older. As such, older children are not only less likely to receive vaccinations, but are also less likely to have their vaccines timeously. Late vaccinations are a particular problem in the West Coast and Central Karoo districts.

The study also fills a crucial gap in the literature by providing information on what factors may enhance social demand for vaccines. Such an understanding is crucial as the significant drop-out between 9 and 18 month vaccines indicates an under utilisation of clinic services in addition to the problems of accessing health services per se. This indicates that we have dual problems of inadequate provision of vaccinations in addition to insufficient social demand (the presumption being that those who could access a clinic at 9 months should be able to access a clinic at 18 months and thus a discrepancy is due to poor social demand for immunisations).

Conclusions

Possession of a Road-to-Health card (RTHC) was the strongest predictor of vaccination status in this study and reaffirms the importance of providing parents with these cards. Furthermore, the study found that parents knew very little about vaccinations, with only 0.2% being aware of the diseases protected by EPI. This represents a significant window of opportunity as caregivers with better knowledge were much more likely to take their children to be vaccinated. From the other side, the commonest reason given for missing a child's vaccine was clinic factors, which included missed opportunities, being told by nurses to come back another time and being given incorrect return dates by clinic staff. Again, this gives a clear indication of where efforts to improve coverage can be targeted.

In terms of equity, this study found equitable vaccination outcomes according to gender and socio-economic status, however major disparities according to race group remain.

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7. Discussion

One of the first considerations in evaluating the validity of this study is the generalisability of the study findings. To confirm that the sample selected was representative of 12-23 month old children in the Western Cape, the demographic features of the sample were compared to those of the 2001 Census[1] (Table 40). The results indicated that the sample was indeed representative of the study population in terms of language and location. Generalisability in terms of the black population group race was slightly more difficult to assess as the Census did not include 'African' as an option for race, however as 55% and 30% of those who described themselves as African and 'Other race' respectively spoke isiXhosa as their home language the approximation to the census was reasonably acceptable (if we assume that those who speak isiXhosa as their home language would class themselves as Black).

	Sample	95% CI	Census
Home Language			
Afrikaans	58.3%	(53-64)	54%
isiXhosa	26.8%	(21-33)	27%
English	14%	(10-19)	17%
Other	1%	(0-2)	2%
Population group			
Black	22.8%	(16-29)	30%
Coloured	56%	(51-61)	58%
White	6.3%	(4-10)	10%
Asian/Indian	0.4%	(0.2-1)	1%
African	4%	(2-7)	n/a
Other	10.9%	(8-13)	n/a
Location			
Rural	10.6%	(8-14)	11.3%
Urban	89.4%	(86-92)	88.7%

Table 5. Comparison of demographic profile of the sample (with 95% confidence intervals) and Census 2001.

Discussion

Immunisation coverage

Overall, the reliability study indicated good reliability of the study tool. The reliability study indicated kappa statistics ranging between 0.6 to 0.78 for vaccination status according to card. Changes in vaccination status may have resulted from real changes in vaccination status over time, the intermittent loss of the Road to Health card between interviews or inaccurate recording by the fieldworkers. In addition to vaccinations naturally becoming due, all children identified to have missed vaccines were referred to the local clinics with a letter requesting vaccination; as such, it was highly likely that vaccination status did indeed change over time. Reliability of vaccinations determined by history was comparable to that by card. However, for vaccines given at later stages (DPT4 and OPV4), the kappa dropped to between 0.3 and 0.46. This finding suggests that as one might expect, caregivers' recall becomes less reliable over time.

However, due to many caregivers not being in possession of a RTHC, it is accepted that one should include 'by history' vaccinations so as to avoid even larger underestimations of immunisation coverage[2,3,4]. Therefore, even though including vaccinations 'by history' is likely to give less of an underestimation of coverage than using 'by card' vaccines alone, it will nevertheless result in a certain degree of underestimation of the number of doses received. It should be noted however that this bias predominantly affects the estimates of vaccinations given at 18 months, which is not the focus of this study.

Another factor likely to result in an underestimation of true coverage was the exclusion of immunisations received during campaigns. Campaign vaccinations were not recorded as the aim of this project was to assess the ability of *routine* services to achieve EPI targets; immunisation campaigns are not a viable source for achieving stable immunisation coverage rates as they are by nature periodic interventions. Nevertheless, actual immunisation coverage of measles and polio

vaccines may well be higher than the estimates presented here as a result of the measles and polio campaign conducted in 2004.

On the other side of the coin, the estimates are also likely to overestimate true levels of immunity. The results presented represent the percentage of 12-23 month old children that are fully *vaccinated* but not the percentage of children who have *immunity*. Children who are vaccinated do not necessarily acquire *immunity* from the vaccine (due to limited vaccine efficiency, administration of expired vaccines and so on)[5] and hence the percentages given below are an over-estimate of the true levels of immunity in the 12-23 month population. The gap between vaccination coverage and immunity may be further widened by the potentially compromised ability of HIV positive children to mount a sufficient immune response to vaccines[6].

Another limitation is that inference was limited for minority groups of the population, such as the white and Asian populations and people whose home language was not Afrikaans, isiXhosa and English; due to the small sample size of these groups, the confidence intervals for their immunisation coverage are wide.

Despite the shortcomings, the results of this study provide the best estimate of immunisation coverage available for the Western Cape. As the coverage remains well below 90%, the Western Cape is at risk for an outbreak of preventable childhood diseases and it is likely that this is also the case for other Provinces in South Africa. Outbreaks would be most likely to occur in 'pockets of low coverage'; at the levels of coverage we see in the Western Cape, these 'pockets' are likely to represent a high risk group of socio-economically disadvantaged children, the so-called 'hard-to-reach' population. It is important to note that this study is only able to give estimates of coverage at district level and is unable to identify variations in immunisation coverage *within* districts which would include these pockets of low coverage. Identifying these pockets through surveys or administrative data remains a challenge and would best be achieved by those working in each area.

Discussion

While these findings give us an indication of immunisation coverage at one point in time, it does not address the problems associated with routine data collection. Comparing the results of the survey with that of routinely collected data, it is clear that the most accurate results can be obtained by using the census method (as seen in Table 2, page 3) rather than the live birth method. Using the census method gives accurate results for both the Boland-Overberg and Southern Cape -Karoo regions, but less so for the West Coast- Winelands region (where it is seen to overestimate coverage). As no information was provided on the Metro region, it is not possible to draw conclusions about the accuracy of their routine data. The estimates presented here should be compared with contemporaneous DHIS estimates in each district to ascertain the accuracy of routinely collected data (this data was requested but has not been provided by the Department of Health).

Factors associated with immunisation coverage

Perhaps the greatest limitation of the findings on factors associated with immunisation coverage is that we cannot impute causality. In cross-sectional studies both the outcome and explanatory factors are measured simultaneously and it is therefore impossible to determine the chronological sequence of associations. In this instance, although many factors have been shown to be associated with vaccination outcomes the direction of the association is undetermined. For example, does increased caregiver knowledge about vaccinations motivate parents to take their children for vaccinations or is it that those who go for vaccinations acquire greater knowledge about vaccines while their children are being vaccinated? It is likely in many instances that the associations are bidirectional (both hypotheses above are likely) however this study design is unable to illustrate the relative strength of association in any one direction. Further research using cohort study designs would be beneficial in this regard.

This study illustrates the substantial impact of caregivers having a RTHC on vaccination outcomes. It could be argued that this finding results from information bias after all; as discussed, caregiver recall tends to underestimate vaccinations given. However, the magnitude of the effect was significantly larger for caregivers with a poor knowledge of vaccines, suggesting that caregivers with a poor knowledge rely to a greater extent on RTHCs to inform their behaviour. If it were only a question of recall bias, we would not expect knowledge to modify the observed effect to such an extent. Given this finding it is reasonable to conclude that while the effect of having a RTHC on vaccination outcomes was probably overestimated, it is nevertheless likely to be a significant factor.

Caregiver knowledge of vaccines (what they protect against, what their purpose is) is another factor that can be used to enhance demand. Knowledge appears to act as a particularly strong motivator where parents have lost the RTHC. Given that approximately 20% of caregivers in the Western Cape do not have RTHCs, properly educating caregivers about vaccines is crucial.

Paradoxically, the success of South Africa's immunisation programme may decrease the demand for vaccinations in years to come. As very few cases of vaccine preventable diseases have been witnessed in recent year[7] caregivers may begin to feel that their children are not at risk for these diseases. This is an important consideration given that whether or not caregivers perceived their child to be at risk predicted vaccination outcomes as has been confirmed in other studies[8]. While the majority of caregivers in this study believe their child is at risk for one or more vaccine preventable disease, this may decrease over time as fewer and fewer cases of disease are seen. Again, this highlights the need to educate parents about potential risks and the need for ongoing immunisations despite apparent 'low risk'.

Clinic factors, including missed opportunities and parents being sent away are the reason most commonly given by parents for not immunising their child. The

findings give a clear indication of the problems experienced by parents at the clinic level but what is lacking are the explanations for these experiences; why are there so many missed opportunities? Why do nurses send caregivers away? Why are the incorrect return dates given? In the context of a health system trying to cope with dual HIV and TB epidemics, trauma and chronic disease, immunisation may be taking a back seat to more salient concerns. This is a common drawback of preventive interventions, where the successes of interventions are judged precisely by what one does not see (the *absence* of illness). If immunisation coverage is to be improved, health workers will need to be convinced of the importance and relevance of vaccination in the era of HIV and TB. There may of course be other explanations for these findings and further research of health care providers is warranted. The reader should also note that this study does not include an analysis of clinic factors that may influence immunisation coverage but are imperceptible to health consumers; there are additional factors that merit consideration such as cold-chain management of vaccines, staff shortages and routine data management.

The findings on clinic factors were not all negative, however and encouragingly, the effect of health care providers' attitudes on vaccination outcomes and knowledge of vaccines provides evidence that health workers attitudes can positively affect health outcomes. This provides support for the 'Batho Pele' policy of improving provider-consumer relations.

The effect of race on immunisation coverage was a disturbing finding. While the overall coverage results for the Province suggest racial equity in vaccination status, the district level data exposes marked racial disparities in coverage in the Boland and Overberg Districts. While the data gives some indication of why we are seeing these differences, they do not completely account for them and further research is warranted. One possible explanation is the effect of migration, where children may have migrated from Provinces where immunisation coverage is low. This hypothesis has been shown to be true in previous studies in South Africa where migrants have

lower immunisation coverage[9]. Although children had to have been living in the Province for at least 6 months to be eligible for the study, it may be that migration effects persist beyond 6 months. As migration status was not recorded in this survey, this factor should be considered however migration effects cannot account for the observed difference in perception of nurses' attitudes at clinics. The effect of language should also be considered given the numerous complaints (particularly in the Boland district) about the lack of isiXhosa speaking staff at clinics. While socio-economic status did diminish the effect of race, it could be that the measures of socio-economic status (employment status, education and monthly income adjusted for household size) are not the best measures of socio-economic status in our context. However, other studies on access to health care in South Africa have found similar racial associations that were also not completely accounted for by socio-economic status alone[10,11].

Conceptual model of factors influencing immunisation coverage

Bearing in mind the categorisation proposed in the introduction, the factors affecting caregivers' vaccination behaviour as seen in this study are summarised in Diagram 1 below. What is immediately apparent is the interaction between variables at different levels, for example knowledge of vaccines can be a function of an individual but is influenced by nurses' attitudes towards parents (at health service level), which may in turn be influenced by the race of the parent (social level). We can postulate that these linkages are likely to hold true for various other factors e.g. it makes intuitive sense that ideas about what constitutes normative behaviour (a social factor) are likely to be moulded by information given by health professionals and the *desire* to act in a normative fashion may be an individual level factor. This synthesis is intended to illustrate the need for addressing immunisation coverage from a multi-level framework perspective.

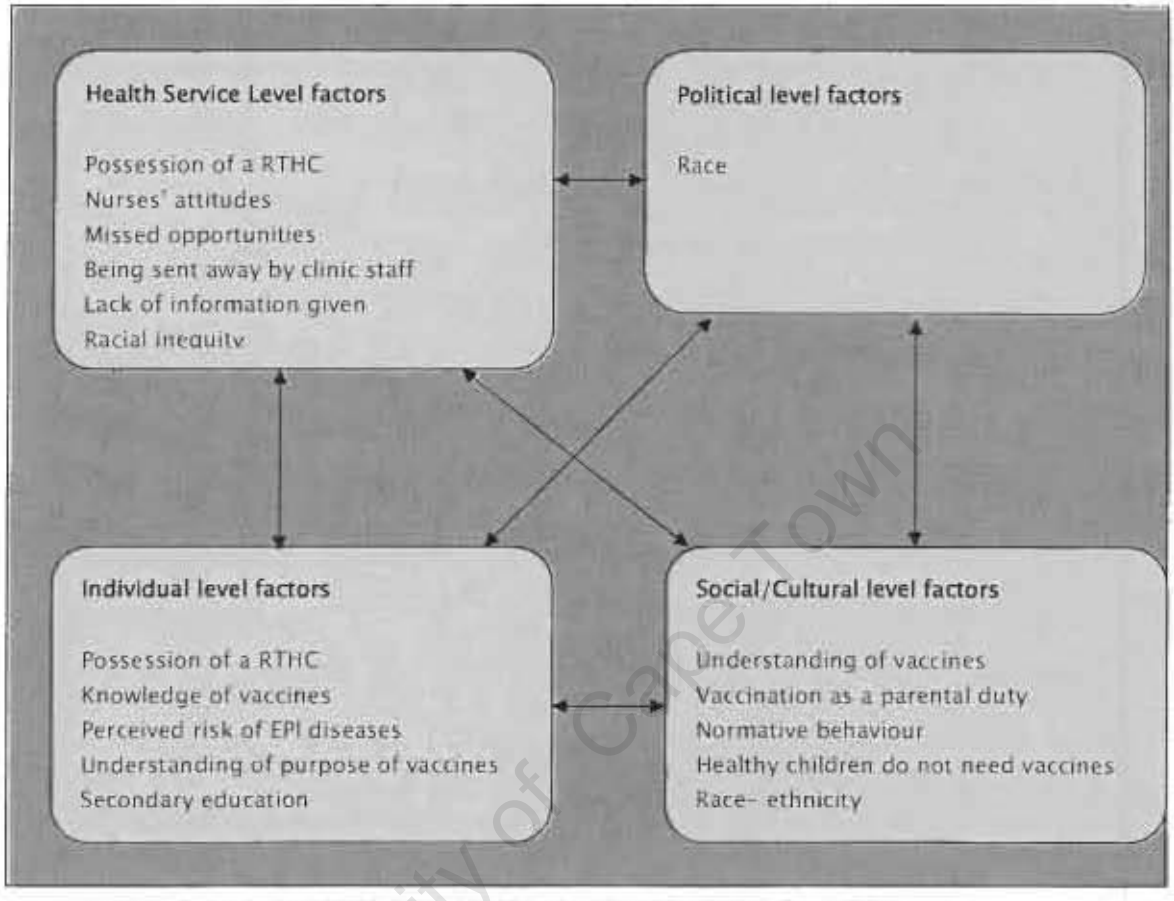

Diagram 1. Summary of factors influencing vaccination status in this study.

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8. Recommendations

Increase vaccination coverage

To enhance the complementarity of immunisation targets and treating disease improving immunisation coverage should contribute to strengthening health services, which will facilitate the success of both preventative and curative interventions. Improving immunisation coverage requires an evaluation of all aspects of the health system: "Immunization services operate within the health systems context and are, like all health care interventions, profoundly affected by the barriers and challenges encountered by the health system as a whole" (WHO, 2005. p.27)[1].

The strategies for improving vaccination coverage are conventionally divided into interventions that target supply and demand[2,3]. As indicated in the discussion, the findings show that coverage in the Western Cape is compromised by problems in both these areas. Reviews of strategies to improve immunisation coverage in developing countries have shown that most strategies are effective in increasing coverage and are cost-effective[2,3]. They note however, that while supply and demand interventions act synergistically, establishing a regular supply of vaccines is a vital prerequisite to initiating demand interventions. Recommendations arising from the study findings have been categorised as demand or supply interventions and highlight the following areas as particularly important:

Recommendations

I. Improve the supply of vaccinations to consumers

1. Ensure accessibility of immunisations

- Provide an adequate supply of vaccinations and equipment to clinics
- Provide sufficient clinic staff, sufficient clinics and mobile services. Improving outreach to 'hard to reach' groups is crucial and the use of community health workers in this regard has been shown to be one of the most effective mechanisms for increasing coverage[1,2]
- Opening hours of vaccination services should be convenient for caregivers (particularly for working mothers)
- Shorten waiting times at clinics
- Ensure that staff and clients are aware that vaccinations can be done at any clinic, such that parents out of their residential area are able to take their child to another clinic for vaccinations. This is particularly important for highly mobile caregivers
- Consider a role for sub-contracting non-governmental organisations to assist in improving coverage[3,3]

2. Decrease missed opportunities

- Train other clinic staff (clerk, pharmacist) to check each child's Road-to-Health card for vaccinations due as they enter the clinic
- Update nurses' training on vaccinations including the true and false contra-indications for vaccinations; peer training has been shown to be effective in other developing country settings[2]. Improving staff supervision is also important[1].
- Educate parents on the safety of vaccines in the context of childhood illnesses (this would need to from part of the education campaigns listed below and detailed in Appendix 8)

- Perform random spot-checks at clinics where children leaving the clinic have their Road-to-Health cards checked for vaccinations
- Put up reminder posters in consultation rooms ("Have you checked the Road to- Health card?")
- Issue reminders to parents when they visit the clinic for other reasons: this would mean linking all members of a family to a family folder, rather than an individual folder. The effectiveness of patient reminder and recall interventions has been demonstrated in two reviews[7,8].

3. Ensure that caregivers attending the clinics for vaccinations are not sent away

- Ensure clinics are properly staffed and fully equipped
- Hold vaccination workshops with clinic staff which highlight the importance of vaccinations in the context of HIV and chronic diseases
- Each clinic should submit the days and times that vaccinations are offered to Province, have these times clearly stated on walls and doors in clinics, and print the times on a card which can be stapled to the Road-to-Health card.
- All clinics should have standardized times for vaccination availability so that caregivers moving around the province always know when the appropriate vaccination time is

4. Foster positive staff attitudes towards clients

- Ensure adequate staffing of clinics (additional person to do vaccines, check Road-to-Health cards)
- Improve staff morale and job satisfaction (through regular positive feedback, providing channels for addressing staff concerns, providing mental-health days for burnt-out staff, adequate salaries, increasing staff social capital and the use of immunisation wall-charts)
- Create a reliable and credible complaints system (Appendix 8)

Recommendations

- Allow consumers to choose which clinic to attend for vaccinations
- Ensure a staff compliment that includes isiXhosa-speaking African staff
- Training of clinic staff with respect to patients' rights
- Training of managerial staff with respect to health professional's rights

5. Decrease racial inequity in vaccination coverage

- Create a reliable and credible complaints system as above
- Allow consumers to choose which clinic to attend for vaccinations
- Ensure a staff compliment that includes isiXhosa-speaking African staff
- Training of clinic staff with respect to patients' rights
- Training of managerial staff with respect to health professional's rights
- Ensure education is provided in African languages as well as Afrikaans and English.

6. Improve timeliness of vaccinations given by ensuring staff and clients understand the importance of timeliness

7. Target areas with the lowest vaccination coverage first and those groups most difficult to reach. As vaccination coverage falls with increasing age, particular emphasis should be placed on vaccinating children at 18 months. Black children and children living in rural areas should be specifically targeted to restore and sustain equity, and to prevent outbreaks in these vulnerable groups.

8. ***Mass campaigns*** for measles and polio should be continued until coverage is sustained above 90%. While the utility of mass campaigns remains controversial, it is clear that immunisation campaigns that improve health infrastructure and are properly timed and well-targeted can improve vaccination coverage[2,3,5,6,7]. In a study of mass campaigns in South Africa, for example, Durrheim et al (2001) suggest that

in order to avoid redundancy, polio campaigns should only be conducted on an annual basis, whereas measles campaigns should be conducted every four years[6]. Campaigns should also ensure they target the hard-to-reach children to avoid wastage of resources on already fully vaccinated children.

9. Ensure the ***collection of reliable data*** on vaccination coverage; identifying pockets of low coverage is crucial and should be undertaken by health workers familiar with the context in small geographical areas.

II. Enhance social demand for vaccinations

Improving community demand is the focus of Strategy 2 of the Global Immunization Strategy devised by UNICEF and the World Health Organisation; " coverage increases if there is community demand and well-informed confidence in the benefits and safety of immunisation and in the need to adhere to a prescribed schedule" (WHO, 2005. p.15)[1]

1. Ensure that all caregivers are provided with Road to Health cards

- The Road-to-Health card should be checked for at every visit
- Lost cards should be replaced free of charge and without reprimand
- Road-to-Health cards should be more user friendly and orientated towards parents rather than nurses (see Appendix 8 for suggested changes)
- Offer new Road-to-Health cards to all parents in communities that have experienced loss of their homes as part of routine disaster management (e.g. in situations of major fires or flooding)
- Issue employers of migrant (seasonal) workers with Road-to-Health cards to distribute to their workers

Recommendations

2. Increase parents' knowledge about the purpose of vaccines, the diseases vaccines protect against, the limitations of vaccines and the importance of repeat doses at specific times[2,3].

- Provincial campaign to raise awareness about the purpose of vaccines and which diseases they protect against (Appendix 8)
- Community-level campaigns to raise awareness about the purpose of vaccines and which diseases they protect against (Appendix 8)
- Clinic-level campaigns to raise awareness about the purpose of vaccines and which diseases they protect against (Appendix 8)
- Individual-level campaign to raise awareness about the purpose of vaccines and which diseases they protect against (Appendix 8)

3. Decrease drop-out rates

- Provide education to clinic staff and caregivers on the importance of repeat doses
- Sustain community demand by ensuring correct understanding of purpose of vaccines
- Trace defaulters
- Ensure safety of vaccines and minimize side-effects (which requires regular monitoring and supervision of immunization practices)

Lastly, provincial and regional immunisation programmes should be addressed as a unit rather than individually taking into account the massive movement of people within and between South Africa. As such, co-ordination of immunisation strategies between provinces and other countries in Africa is paramount.

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