CHILDHOOD VACCINATION COVERAGE AND ITS DETERMINANTS IN KHAYELITSHA

Submitted in partial fulfillment of the requirements for the degree of Master of Medicine in the Department of Community Health of the University of Cape Town

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1992

DECLARATION

I, Nicol Coetzee hereby declare that the work on which this thesis is based is original (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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ABSTRACT

The purpose of the study was to ascertain the vaccination coverage of children aged 12-23 months living in Khayelitsha, a peri-urban township of Cape Town, and to identify factors associated with measles vaccination coverage. A stratified proportional cluster sampling technique was used to select 46 clusters of 10 children each.

Three distinct residential areas were defined as study strata and the vaccination status of each sampled child was determined from the preschool (i.e. Road to Health) cards. Usable information was obtained for 432 children; in 75.4% of cases the respondent was the child's mother, and 69.4% of children possessed a preschool(Road to Health) card.

54.6% of children were fully vaccinated and measles vaccination coverage was 63.5% (95% confidence interval(CI) 58-67). Three factors were found to have had a significant association with incomplete measles vaccination: less than 6 months' residence in the area (odds ratio (OR) 3.1; 95% CI 1.9 - 4.9), having been born outside Cape Town (OR 2.5; 95% CI 1.6 - 3.9), and home delivery (OR 2.0; 95% CI 1.1 - 3.6). Maternal educational level and the age of children were not associated with measles vaccination status.

Children in the underserved New Shanty area were identified as a high risk group with lower vaccination coverage and more cases of measles. Carers of children in the New Shanty area were the least likely to be aware of the importance of measles vaccination and to have been visited by a community health worker.

In order to improve the inadequate vaccination coverage levels, the challenge facing the health service in Khayelitsha is to develop the capacity to reach children identified as belonging to high risk groups.

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ACKNOWLEDGEMENTS

I would like to thank the following individuals and groups. Without their help and guidance this study would not have been possible:

- Derek Yach - my supervisor who served as a constant source of wisdom and inspiration.

- Stewart Fisher - for making the field staff and facilities of the Western Cape Regional Services Council (WCRSC) available to me, and for useful comments on earlier drafts of the report.

- Gladys Macaba - who acted as field coordinator and my link to the local community.

- The team of interviewers from the WCRSC - for their enthusiasm and dedication.

- Ronette Blignaut - for assisting in the statistical analysis of results and for her advice on methodology.

- Carol Metcalf - for useful comments on earlier drafts of the report.

- Judy Katzenellenbogen - for her advice on questionnaire design and interviewer training.

- Members of the Centre for Epidemiological Research in Southern Africa of the Medical Research Council(MRC) - for useful comments on the study protocol.

- Members of the Department of Community Health of the University of Cape Town - for their support and useful comments during all stages of the investigation.

- The MRC - for financial assistance.

- Mariaan Swart and Ronell Slabber - for assisting in preparation of the manuscript.

- Tandi, my wife - for assisting me in coding questionnaires, her constant encouragement, and in giving so freely of her valuable time.

- The children and their families of Site C and Green Point - for their patience and eagerness to participate in the study.

DEFINITIONS AND TERMINOLOGY

Vaccination and Immunisation:

"Vaccination" is the process whereby antigens are offered to the immune system of human subjects with the aim of conferring protective immunity. "Immunisation" occurs when vaccination has been successful and the recipient has developed protective immunity to the vaccine antigen.[1]

When the vaccine has been administered to a subject "vaccination" has taken place. The vaccination procedure is then usually recorded (on the Road To Health Card in the case of children) by the health worker for future reference. "Immunisation" has occurred when protective immunity has developed after vaccination, and has to be measured serologically.

Vaccination coverage:

The proportion of all children in the target population who are vaccinated at a point in time. Documented proof of vaccination, as recorded on the child's pre-school card or "Road to Health" card (RTHC) was required for the purposes of determining vaccination status.

Age:

Age was calculated from the date of birth of children as recorded on the RTHC, or birth certificate. If no documented proof of birth date was available the care givers were asked to estimate the child's age.

Age range 12-23 months:

Includes all children who had already had their first birthday, but who had not yet had their second birthday.

Resident of Site C of Green Point:

Children who have lived in Site C or Green Point constantly for longer than 4 months (thus excluding overnight visitors).

Child Minder:

Person assuming parental responsibility for the day to day care of the child.

Fully vaccinated:

Children in the study population(aged 12 - 23 months) who have documented proof of having received all the following vaccines at the time of the survey:

- Bacille Calmette-Guerin(BCG); dose 1
- Oral polio vaccine (OPV); doses 1,2 and 3
- Diphtheria, Pertussis and Tetanus(DPT); doses 1,2 and 3.
- Measles; dose 1.

Vaccination schedule:

The policy regarding age of vaccination in Khayelitsha up to the time of the survey was as follows:

- BCG		: at birth
- DPT/Polio	1	: 3 months
	2	: 4.5 months
	3	: 6 months
- measles	1	: 6 months
	2	: 9 months

Monovalent OPV given at birth was not part of the vaccination schedule at the time of this study.

Cluster:

A group of 10 children aged 12-23 months living in close proximity to each other and sampled according to the EPI methodology for the purpose of evaluating vaccination coverage.

Household:

A free standing dwelling (permanent or temporary construction) including its occupants. Backyard shacks were taken to be separate households if occupied by permanent inhabitants.

The study area did not contain any high rise or complex housing designs (apartments) and therefor a more stringent definition of a household was not necessary. In the case of apartment complexes and high rise housing structures the EPI has recommended that the household be defined as "a group of people who share the same kitchen".[2]

Community Health Worker(CHW):

A lay health worker from the community who has a basic training in primary health care promotion. The CHWs working in the study population were employed and trained by the WCRSC.

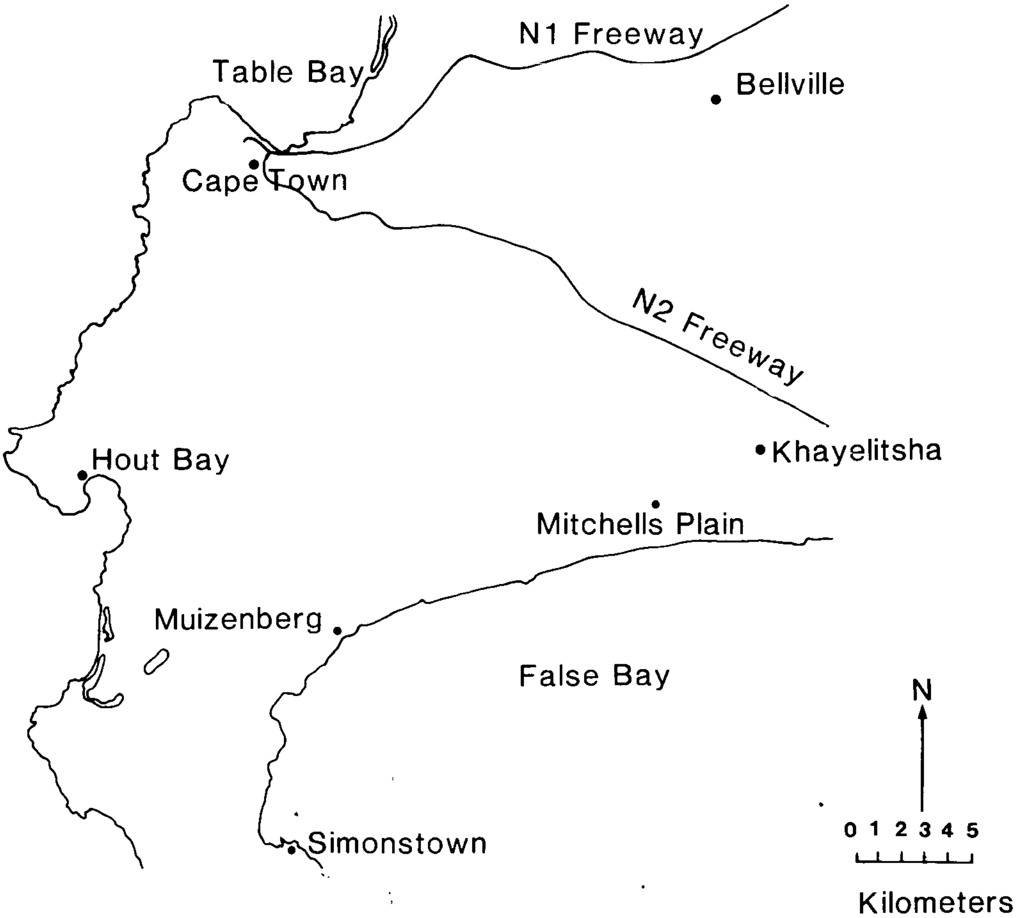
1. INTRODUCTION

During 1988 the local authority responsible for rendering health services in Khayelitsha (i.e. Western Cape Regional Services Council (WCRSC)) expressed concern about the difficulty experienced in adequately evaluating and effectively directing the vaccination programme in the area.

Khayelitsha(a peri-urban township situated 20 km from the Cape Town city centre) is in the process of rapid urban expansion (Fig.1). The influx of migrants and accelerated population growth results in routine vaccination data often being out-dated by the time it is collected and processed by the health service. The accuracy and completeness of routinely collected health information and vaccination data is also of questionable value.

These unstable conditions of high population mobility so typical of the urbanisation process have been a major factor in hindering the health services from reaching and vaccinating all children. It was felt that factors determining the vaccination status of children in Khayelitsha were poorly understood and therefore effective corrective action could not be taken. The perception of child minders concerning the importance of vaccinating children was not known, and so too their sources of information on vaccination had to be identified.

Fig 1: Location of Khayelitsha in relation to metropolitan Cape Town



Attitudes and beliefs about vaccination needed to be assessed as these could be important impediments to vaccination. To direct vaccination services more effectively and to achieve sustained herd immunity, the above factors had to be identified as the first step towards implementing corrective action.

To address the above inadequacies of routine data and to effectively plan, target and evaluate the vaccination programme in Khayelitsha, an epidemiological investigation of vaccination coverage was undertaken. The study was requested by the WCRSC and was a collaborative project between the Department of Community Health (University of Cape Town), the Centre for Epidemiological Research in Southern Africa (Medical Research Council) and the WCRSC Health Department.

1.1 Study Aim

To determine the vaccination coverage of children aged 12-23 months in Khayelitsha, and to identify factors associated with incomplete measles vaccination.

1.2 Study Objectives

1.2.1 To determine the following demographic characteristics of children in the study population:

- age
- sex

- level of schooling of child's mother
- availability of child's 'Road to Health' card
- the proportion of children born at home
- region where child was born
- length of stay in study area.

1.2.2 To determine the proportion of child minders who had been informed about the importance of having their children vaccinated against measles, by the following variables:

- region of birth of the child
- area of residence within Khayelitsha
- home visit by a community health worker
- duration of stay in Khayelitsha

1.2.3 To determine the child minders source of information on the importance of measles vaccination.

1.2.4 To determine the level of understanding of child minders concerning the preventive nature of measles vaccination.

1.2.5 To determine the proportion of children aged 12-23 months, resident in Khayelitsha (Site C and Green Point) at the time of the survey, who had received the following vaccinations:

Bacille Calmette-Guerin(BCG): dose 1

Measles: dose 1

Oral Polio Vaccine(OPV): doses 1,2,3

Diphtheria: doses 1,2,3

Pertussis: doses 1,2,3

Tetanus: doses 1,2,3

1.2.6 To determine the association between the measles vaccination status of children and the following variables:

- age of child
- level of schooling completed by child minder
- institution of birth (home or hospital/clinic)
- region of birth of child
- duration of stay in Khayelitsha
- area of residence within Khayelitsha

Even though the vaccination coverage of all six childhood vaccines was evaluated, the study did focus on measles vaccine in identifying the determinants of vaccination coverage. The reason for this is that measles has an unacceptably high morbidity and mortality in urban areas, and is seen as a priority for control by the local health services.[3-6] It is also reasonable to assume that the determinants of measles vaccination coverage are not significantly different from that of the other childhood vaccines.

2. LITERATURE REVIEW

2.1 Global Perspective

"Immunisation is one of the most powerful and cost-effective means of preventing disease but remains tragically underutilised".[7] There can be few other strategies for improving health that are as dramatic in achieving their goals as immunisation. A small number of contacts with the health service produce a long term effect, a feature of particular relevance in underserved communities.

Because of these features, immunisation was chosen by the first World Summit for Children as one of the twenty specific targets to "end child deaths and child malnutrition on today's scale by the year 2000".[8] Immunisation has an additional advantage in that it prevents many of the infectious diseases that are contributory to childhood malnutrition. The means of ending the "quiet catastrophe" of 40 000 child deaths in the world each day are available, and immunisation has a central role to play.[8]

2.1.1 Extent of the Problem

The morbidity and mortality related to childhood vaccine preventable diseases is particularly severe in the developing world and contributes to roughly 25% of child deaths annually.[9,10] The case fatality ratio for measles in the developing world is 2% on average, more than a hundred times that of Europe. Polio, whooping cough and neonatal tetanus have virtually been eradicated from industrialised countries, but remain highly prevalent and a threat to public health in developing regions (Table 1).

2.1.2 The Expanded Programme on Immunisation (EPI)

To address this problem of excess morbidity and mortality due to vaccine preventable diseases the World Health Organisation (WHO) established the Expanded Programme on Immunisation (EPI) in 1974.[7,12] The success already experienced in the narrowly focused smallpox eradication campaign at this time, served as stimulus to start work on the expansion of existing immunisation services.[9,13] Expansion both in terms of the number of antigens used and the extent of coverage.[9]

The objective of the EPI as defined in 1977 was to reduce morbidity and mortality from diphtheria, pertussis, tetanus, measles, poliomyelitis and tuberculosis by making vaccination against these diseases available to all of the world's children by 1990. For practical purposes this goal of universal vaccination was taken to mean reaching 80% of the developing world's children with these six vaccines, before their first birthdays. The coverage of children with three doses of DPT vaccine(DPT-3) is considered by the WHO to be a good indicator for evaluating overall

TABLE 1

ESTIMATED ANNUAL NUMBER OF DEATHS FROM NEONATAL TETANUS, MEASLES, AND PERTUSSIS AND ANNUAL NUMBER OF CASES OF POLIOMYELITIS IN DEVELOPING COUNTRIES (EXCLUDING CHINA), JANUARY 1986.

	No. of deaths (X 1,000)			
	Neonatal tetanus	Measles	Pertussis	Polio cases (X 1,000)
Developing countries:				
25 largest	663	1,721	471	212
Other	176	389	128	60
Total	839	2,110	599	272

Adapted from reference 11

vaccination coverage.[8]

The EPI forms an important part of the WHO's strategy to achieve "health for all by the year 2000", and childhood vaccine coverage is being used as one indicator for evaluating success of this strategy on a global scale.[7]

2.1.3 Problems Encountered by the EPI

From the start it was clear that the EPI did not have to wait for any major research breakthroughs in order to reach its goals. Effective, safe and cheap vaccines were already available.[7] What was lacking however was political will, managerial expertise and technical support.[13] These are all essential components to ensure that the correct vaccines get into the target children at the appropriate time.

One of the major functions of the EPI has been to persuade governments of the priority that immunisation should receive in their health services, and the importance of allocating adequate funds and personnel on a consistent basis. Once the political will had been mobilised the scarcity of skilled managers had to be addressed. The training of mid-level managers and health workers received priority, for without a critical mass of expertise individual country based programmes could not be implemented and coordinated.[12]

To ensure the delivery of potent vaccines to the periphery, a considerable amount of technical support had to be developed. The maintenance of a cold chain, supply of needles and syringes, sterilization methods and safe disposal of used needles are all aspects that had to be addressed, taking account of local variations.[13]

Information systems for evaluating progress of the programme had to be developed. The three principal indices used for monitoring progress of the EPI were: vaccination coverage, incidence of target diseases, and quality of vaccines in use.[14] Initially vaccination coverage was assessed using routine reports on numbers of doses of vaccine administered. More accurate estimates were required, leading in time to the development and use of a standardised cluster sampling survey method.[15]

The monitoring of target disease incidence on a global scale has proved to be difficult. Official disease reporting systems are often weak, with long delays and severe under-notification of cases.[7] For this reason the EPI has decided to focus global disease surveillance efforts on poliomyelitis, measles, and neonatal tetanus. These three diseases are expected to be the most easily diagnosed and the most influenced in the short term by vaccination programmes.[7]

In many areas "sentinel" surveillance sites are now used to supplement routine reporting systems for these three diseases.[7] Trends in global incidence of EPI target diseases are difficult to follow accurately and country specific trends are often more accurate and reliable over time. Because of these reasons no clear picture has as yet emerged from monitoring global trends.[16]

2.1.4 Primary Health Care Perspective of the EPI.

A vertical single purpose programme may be the only way of establishing a priority health service, such as immunisation, in a developing region. However, long term success of any programme will depend of acceptability to the community. Full integration of the EPI with the primary health care services is recognised as the only way of ensuring eventual goal attainment and acceptance by the local population.[13]

Immunisation services are also delivered most effectively in combination with other primary health care services such as those rendered to children and pregnant mothers. In many underserved areas where the EPI has been promoted in the context of primary health care, it has directly contributed to the strengthening of other services and programmes. The GOBI-FFF (an acronym for growth monitoring, oral rehydration, breast-feeding, immunisation, family spacing, food supplementation and female education) programme is the leading example of integration of the EPI with other primary health care interventions.[17]

2.1.5 Progress Made by the EPI

The EPI's achievements so far are a major public health success. When the programme was initiated in 1974 it was estimated that coverage of infants with a third dose of DPT or polio vaccines was less than 5% in the developing world.[12] Since then a more reliable vaccination coverage estimation system was developed, and by 1987 coverage for DPT-3 had reached approximately 50% in the developing world (Table 2).[12] This level of success meant that immunisation in developing countries was preventing 200 000 children from becoming paralysed with poliomyelitis and over a million deaths from measles, neonatal tetanus, and pertussis.[18]

It had taken 15 years to reach the 50% coverage mark, was it still possible to reach the 80% or more target level by 1990? The need for an "acceleration" of the EPI was apparent. The EPI Global Advisory Group recommended more specific actions and the strengthening of national programmes.[12] The training of immunisation managers and integration with primary health care services was seen as a priority and essential for ensuring a sustained effort. Vaccinations were to be provided at every contact point and the drop-out between first and last doses had to be reduced. A coverage level of 50% for DPT-3 means that approximately 70% of children are in contact with a health worker and are receiving a first dose of DPT.[18]

TABLE 2

GLOBAL DPT-3 VACCINATION COVERAGE FOR CHILDREN < 1 YEAR OF AGE, 1974 -1990.*

	DPT-3 vaccination coverage(%) by year						
	'74	'78	'84	'85	'86	'87	'90
Selected developing countries:							
India					51	53	79
China					63	62	95
Indonesia					6	48	71
Nigeria					-	21	47
Bangladesh					2	5	54
Brazil					2	52	54
Ethiopia					7	7	26
Zaire					16	32	38
Mexico					52	34	65
All developing countries (total)	5				43	49	71
Industrial countries (total)					62	71	86
Global total		25	28	46	46	52	72

Adapted from references 7, 12, 16, 18, 19.

* Data incomplete for 1974, 1978, 1984, 1985.

DPT-3 = third dose of DPT vaccine.

To reach the 1990 target global efforts also had to become more focused. In 1987 coverage with DPT-3 was the lowest in Africa (27%), the WHO region with the least developed health infrastructure (Table 3).[18] A further priority was to concentrate on regions where the highest density of children are found. Over 40% of all the world's infants live in four countries: China, India, Indonesia, Nigeria. India alone contains 20% of the world's infants. Nigeria is the least advantaged of the four with the lowest vaccination coverage (21%) in 1987, and would need special attention from the EPI in future (Table 2).[18] Ethiopia and Bangladesh were also identified as priority areas, both had vaccination coverage of less than 10% in 1987 (Table 2).

By 1990 the true outcome of the accelerated EPI efforts became apparent - more than 70% of infants in the developing world had been vaccinated with DPT-3 (Table 2). Even though there is a short-fall of some 10% in reaching the 1990 target, this does not detract from the magnitude of this achievement.[19] These levels of vaccination coverage mean that an estimated 2.6 million deaths from measles, neonatal tetanus and pertussis and 410 000 cases of poliomyelitis are prevented each year.[19]

2.1.6 The EPI After 1990

This achievement in 1990 should not be seen as a finishing point, but rather as a "starting date for the ongoing vaccination of all children of the world".[12] The

TABLE 3

DPT-3 VACCINATION COVERAGE FOR CHILDREN < 12 MONTHS OF AGE BY WORLD HEALTH ORGANISATION REGION, 1987 AND 1990.

	DPT-3 vac. coverage (%)	
	1987	1990
Region:		
Africa	27	43
Americas	51	69
Eastern Mediterranean	57	72
Europe	76	82
South-East Asia	47	74
Western Pacific	70	88
Global	53	72

Adapted from references 12, 19.

Forty-Second World Health Assembly has set new targets for the EPI in the 1990's to ensure that no momentum is lost. A target of 90% vaccination coverage by the year 2000 is to be achieved.[19]

The primary concern of the EPI is not vaccination coverage, but disease control.[19] The control of target diseases is therefore to receive priority: global eradication of poliomyelitis by the year 2000; a 90% reduction in measles cases compared to pre-immunisation levels by 1995; and the elimination of neonatal tetanus by 1995.[20] Improving disease surveillance systems, introducing new improved vaccines (cheaper, heat stable, fewer doses), promoting other primary health care practices (micronutrient supplementation), and promotion of research and development were all seen as priority areas in the next decade.[19,21]

2.2 South African Perspective

2.2.1 Disease Trends

Even though undernotification is a major problem and denominators are often inaccurate, trends in the incidence rates of five of the six EPI target diseases in South Africa were examined in a recent study.[22] Pertussis was excluded from this review as it is not a notifiable disease in South Africa and its incidence can therefore not be readily determined.[23] During the period 1974 - 1986, diphtheria and poliomyelitis were the only two EPI target diseases that showed a sustained and significant reduction in incidence in South Africa.[22]

No discernable reduction in the incidence of measles, tuberculosis and tetanus could be detected during the same period. Using the measles incidence data given by Ijsselmuiden et.al.,[22] one can calculate the slope on the regression line to be approximately 4% per year, implying an optimistic projected date of control in about 15 years.[24]

Considering the notification figures (not rates) of the EPI diseases gives some idea of the relative importance and magnitude of the problem in South Africa (Table 4). This is particularly so when bearing in mind that both reported cases and deaths only represent a fraction of the true situation. Of concern is that between 10 and 22 thousand cases of measles are reported annually and that between 280 and 450 children die of the disease each year (Table 4).

The prime reason for the slow reduction in incidence of the EPI target diseases in South Africa does not lie in the absence of effective vaccines, but rather in failure on the part of health services to evaluate vaccination programmes and achieve adequate vaccination coverage.[6,26]

TABLE 4

NOTIFIED VACCINE PREVENTABLE DISEASES (CASES AND DEATHS), SOUTH AFRICA, 1985 -1989.

	Number of cases (deaths)* by year				
	1985	1986	1987	1988	1989
TB	49262	46301	57406(2381)	54093(2076)	58046(1883)
Polio	66	40	25(1)	169(4)	11(0)
Dipht.	44	17	28(0)	19(4)	7(0)
Tet.	216	152	237(77)	166(84)	115(33)
Measl.	14537	10596	22559(449)	13544(282)	15004(310)

Adapted from reference 25.

* Notified deaths given in brackets following case notifications

Key: Dipht. = diphtheria
Tet. = tetanus
Measl. = measles
TB = tuberculosis

2.2.2 Vaccination Coverage - Local Studies

Because of South Africa's exclusion from the WHO and therefore also the EPI activities, there has been a delay in targeting resources in order to prevent childhood infections. A major drawback has been the reliance (especially on a national scale) on routinely collected vaccination coverage data as an evaluation tool.

Routine data is known to have many serious inadequacies and tends to overinflate vaccination coverage estimations because of target population underenumeration.[22,27] The lack of accurate evaluation and fragmentation of health services has resulted in poor planning and coordination of the national vaccination programme.[6,22]

As a departure from the use of routine vaccination coverage data, a number of local EPI-type vaccination coverage surveys have been done in South Africa since 1985.[15] These results are summarised in Table 5

It is hard to draw any reliable conclusions from this scanty and diverse collection of data sets. What is surprising is the number of rural areas (Gazankulu, Bophuthatswana and Hewu) with very high coverage rates. This is most certainly a reflection on the availability of good primary health care services and adequate health service infrastructure. By contrast, rural areas with underdeveloped health services (Praktiseer, Lebowa,

TABLE 5

VACCINATION COVERAGE EVALUATIONS USING EPI METHODOLOGY (CHILDREN 12-23 MONTHS OLD), SOUTH AFRICA, 1985 -1990.

Year	Area	BCG %	Polio3 %	Measles %	All %
1985	Gazankulu[1]	95	92	85	-
1985	Boph'tswana[28]	87	72	81	66
1986	Ingwavuma[29]	74	48	38	-
1988	Transkei[30]	89	55	47	30
1988	Hewu[31]	-	-	-	70
1988*	Khayelitsha[32]	-	-	55	-
1989	Edendale[33]	87	62	58	53
1989	Laudium[34]	99	98	87	86
1989	Mamelodi[35]	-	74	76	70
1989	Eersterus[36]	98	92	89	88
1989	Praktiseer[37]	69	56	48	35
1989	Lebowa[38]	77	57	47	-
1990	Hillbrow[39]	78	75	70	-
1990**	Khayelitsha[40]	-	-	64	-

* 6 - 23 months
** 6 mth - 5 yr

Adapted from reference 25.

Transkei and Ingwavuma) have markedly lower vaccination coverage rates (Table 5).

Urban and peri-urban areas with poor heath delivery systems and in the process of urban expansion (Edendale, Khayelitsha) have lower vaccination coverage rates than more established areas (Hillbrow, Eersterus, Laudium, Mamelodi). The results in Table 5 highlight the importance and use of area specific coverage estimates in identifying priority areas with the purpose of better directing vaccination services.

2.2.3 National Vaccination Coverage Evaluation

During 1990 a national measles vaccination campaign was implemented and coordinated by the Department of National Health and Population Development. Prior to the campaign vaccination coverage levels were evaluated for the whole South Africa using EPI cluster sampling methodology.[11] This is the first time that vaccination coverage estimates, derived from EPI methodology, have been available on a national scale (Table 6).

As can be expected the BCG coverage levels are higher than any other, and only QwaQwa has a coverage rate below 75%. DPT-3 or polio-3 coverage estimations serve as indicators of the success of the vaccination programme. The overall level for polio-3 (65%) is surprisingly high. Only three areas out of nine had a levels over 70%, indicating that a

TABLE 6

VACCINATION COVERAGE OF CHILDREN 12-23 MONTHS OLD BY REGION, SOUTH AFRICA, 1990.

Region	BCG %	Polio3 %	Measles %
Cape	98	83	72
Natal/KwaZulu	84	65	59
OFS	85	61	59
Transvaal	88	75	73
KaNgwane	82	63	61
QwaQwa	64	33	61
Gazankulu	86	78	64
Lebowa	77	59	46
KwaNdebele	82	69	64
Total	83	65	62

Adapted from reference 11.

lot of work has still to be done before polio is eradicated from this country.

Measles vaccination levels are the lowest of all with an average of 62%. Seven out of nine areas have levels below 65%. These findings are of grave concern because in order to break transmission coverage levels of 80-85% and 92-95% are needed for polio and measles respectively.[41]

Apart from some obvious methodological deficiencies (uncertain reliability, validity and sampling bias) the major short coming of this national evaluation is the lack of fine stratification. A broad stratification into urban and rural segments was undertaken.[11] This is of limited value because no differentiation was made between large cities and peri-urban areas in the process of urbanisation, and towns or villages.

Stratification by population group (Table 7) revealed that blacks have coverage levels that are consistently lower than the other population groups.

2.2.4 Neighbouring Countries

Comparing the national pre-campaign vaccination coverage levels to that of some of South Africa's neighbours is useful in gaining perspective on local achievements to date (Table 8). Mozambique and Angola have a long way to go in attaining adequate herd immunity. The effects of a

TABLE 7

VACCINATION COVERAGE OF CHILDREN 12-23 MONTHS OLD BY POPULATION GROUP, SOUTH AFRICA, 1990.

Population Group	BCG %	Polio3 %	Measles %
Asian	95	87	87
Black	84	66	60
Coloured	98	87	82
White	93	86	73

Adapted from reference 11.

TABLE 8

VACCINATION COVERAGE OF CHILDREN 12-23 MONTHS OLD FOR COUNTRIES NEIGHBOURING SOUTH AFRICA, 1988/1989.

Country	BCG %	Polio3 %	Measles %
Mozambique	51	39	48
Angola	46	19	42
Zimbabwe	80	75	70
Lesotho	78	81	75
Botswana	99	88	80

Adapted from reference 8.

concerted effort by the EPI in Botswana and Zimbabwe is apparent in that they have overall coverage levels that exceed those in South Africa.

2.3 Determinants of Vaccination Coverage

From the preceding discussion it is clear that the success of the EPI depends on achieving high and sustained vaccination coverage levels. Studies reporting only on vaccination coverage levels are useful in evaluating overall programme success, but lack the detail needed to target and adjust interventions more effectively. Factors in the environment, the health service (vaccination programme) and the population that have an influence on vaccination coverage need to be identified. Knowledge of these factors (determinants) will make it possible to design appropriate interventions necessary for achieving high enough vaccination coverage levels for eventual control and even eradication.

The determinants of vaccination coverage for a number of local and overseas studies are summarised in Table 9. This is by no means a comprehensive table of all studies identifying determinants of vaccination coverage. It does however include most of the published work in South Africa since 1985 and some relevant studies from other parts in Africa.

TABLE 9

DETERMINANTS OF CHILDHOOD VACCINATION COVERAGE: A SUMMARY OF THE FINDINGS FROM SELECTED STUDIES, SOUTH AFRICA AND AFRICA.

Place	Determinant	Test**	Result*
Gelukspan[55]			
	Clinic visits	t	$p<0.001$
	Knowledge, schooling, marital status, planned pregnancy, place of delivery.		NS
Bophuthatswana[28]			
	Reasons given: guardian problems 33-39% socio-economic 21-27% poor health education 15-16% distance to clinic 4-9%		
Mosveld[29]			
	Distance from clinic	Chi	$p<0.05$
Edendale[33]			
	Peri-urban area lowest	Chi	$p<0.05$
Alexandra[57]			
	ANC attendance	Chi	$p<0.0002$
	Living outside Alex.	Chi	$p<0.02$
	Sex, support from father, sibling death, no. of sibs, maternal age.		NS
Khayelitsha[32]			
	Living in Cape Town < 4 mths	Chi	$p=0.003$
Hillbrow[39]			
	Born outside Johannesburg	Chi	$p<0.005$
	Reasons given: lack of information 29% lack of motivation 4% obstacles (distance etc) 67%		
Hewu[31]			
	Born at home	Chi	$p<0.003$

TABLE 9 (CONTINUED)

Praktiseer[37]			
	Length of time child was supervised by child minder	Chi	p<0.01
	Level of maternal education		p<0.01
	Walking distance from clinic		p<0.01
Khayelitsha[40]			
	Period of residency < 6 mths	OR	1.2-4.0
	Home birth		1.2-8.4
	Region of birth	Chi	p<0.004
Urban Senegal[59]			
	Level of maternal education	Chi	p<0.05
	Socio-economic status		p<0.05
	Ethnic differences		NS
Urban Guinea[58]			
	Born in hospital	OR	1.6-5.7
	Maternal age < 35 yrs		2.0-5.9
	Turned away from vaccination		1.8-10.6
	Short waiting time		1.6-6.1
	Knows child with vaccination abcess		1.1-4.6
	Maternal employment status		3.6-78.7
	Speaks French		1.4-12.9
Urban Mozambique[51]			
	Knows child with vaccination abcess	Chi	p<0.01
	Born at home		p<0.05
	Period of residency < 1 year		p<0.01
	Days/week vaccination offered		p<0.01
	Distance to clinic		p<0.01
Rural Mozambique[51]			
	Born at home	Chi	p<0.01
	Mother not speak Portuguese		p<0.05
	Maternal knowledge of diseases		p<0.05

Adapted from reference 25.

** statistical test
* statistical significance

Key: Chi = chi-square test
NS = not statistically significant
OR = odds ratio
ANC = antenatal clinic

2.3.1 Urbanisation

The process of urbanisation has in recent years developed as a major challenge to the control of childhood infectious diseases. By the year 2000 more than half of the world's population will be living in urban areas, with the highest rates of urbanisation taking place in Africa.[42,43]

In South Africa rapid expansion has occurred in several cities since the lifting of influx control legislation in 1986. The proportion of blacks living in urban areas in South Africa (40% at present) is expected to double by the turn of the century.[44] Kearney has reported the rate of influx of young children to Khayelitsha (Cape Town) to be as high as 9.1% per month in 1988.[32] This rapid tempo of urbanisation in South Africa and Africa is putting even more pressure on already over-extended health services.[42]

At first glance, cities appear to have a number of advantages above rural areas that could enable the delivery of vaccines: smaller distances; easy communication and supervision; better schooling and higher levels of education of the population; better health facilities and more personnel.[45] These advantages do not hold true when a closer examination is made of intra-urban differences.

Urbanisation in Africa is taking place under poor economic conditions leading to extensive urban poverty and under-development.[43,45] In many cities in Africa and

South Africa, the poor constitute the majority of the population and health and environmental services are far from adequate.[45]

Because of these trends the WHO and UNICEF have identified urban areas (especially peri-urban squatter and slum areas) as a priority for improving the EPI and primary health care delivery, thereby making the achievement of "health for all by the year 2000" more of a reality.[46] In 1989 the Global Advisory Group of the EPI recommended that national and municipal programme managers develop action plans to reach urban populations.[45]

The epidemiology of target diseases in urban areas call for enhanced and focused control strategies. In cities in the developing world there is a constant supply of susceptible infants and children because of high birth rates and immigration from rural areas. These factors together with crowded living conditions result in a sustained and endemic disease transmission pattern.[45,47]

The spread of highly contagious disease, such as measles is facilitated by a high density of susceptibles. A higher and more sustained vaccination coverage will therefore have to be achieved in crowded urban settings, compared to rural areas, if disease control is to be realised.

Endemic urban areas also serve as a reservoir for measles transmission via migrating children, to rural areas.

Improving vaccination coverage in urban areas will therefore have potential benefits for disease control in rural areas.[48] The high density of susceptible children in urban areas also leads to transmission of measles at a younger age, soon after loss of maternal antibodies.

In Kinshasa and Natal/KwaZulu up to 45% of measles cases occur in children under one year of age.[5,49] The young age, large infecting dose due to overcrowding, and compromised status (i.e. malnutrition) of children in urban slums results in a higher case fatality rate from measles in urban areas.[3,5,48,50] Adequate measles control in urban complexes will therefore have a greater impact on mortality than in rural settings.[45]

There is a general misconception that the unreached children are to be found in remote villages and rural areas. One of the most striking features about recent vaccination coverage estimations is that a number of rural regions appear to have higher vaccination coverage rates than in urban or peri-urban areas.[33,51] The lower coverage in urban areas is an international phenomenon attributed to "high migration rates, lack of social cohesion and friction between new immigrants and established authorities" in slum areas.[46]

In the Vulindlela/Edendale regions of KwaZulu the rural measles vaccination coverage (70%) is almost double that of the peri-urban areas (38%).[33] A 1989 Cape Province survey reported the measles vaccination coverage for black children to be 54% in urban areas as opposed to 69% in the rural stratum.[52] The assumption is strengthened by a recent evaluation of the vaccination outreach programme in Mozambique with reported coverage estimates of 82% in rural areas and 74% in urban settings.[51] Residence in these large peri-urban areas can therefore be viewed as a determinant of vaccination coverage in its own right.

There are of course many rural areas where the old impression still holds, with measles vaccination coverage being extremely low. In such areas basic primary health care delivery is lacking, such as is found in Transkei,[30,53] and distances are great such as on the Orange Free State farms.[54] In contrast, in rural areas where services are uniform and comprehensive and involve the effective use of mobile outreach programmes and/or village health workers remarkable results have been achieved.[1,31,55,56]

Apart from residence in the city, other factors related to migration to the city and urbanisation, have emerged as important determinants of vaccination coverage. Recent arrivals in the city[32,40,51] and having been born outside the city[39,40] are both determinants of low vaccination coverage. The high migration rates, population mobility and seasonal population migration make it difficult for vaccination services in cities to reach children and trace defaulters.[45]

2.3.2 Access to Health Care

The ease with which mothers gain access to vaccination services is a major factor in deciding the potential coverage that could be achieved. In rural areas the great distance that has to be travelled to reach immunisation services[28,29,37] is obviously a far greater obstacle, but physical distance remains important in urban areas.[39,51,57] The concept of social distance is also crucial, both in rural and urban areas, predominating in the latter. Cultural (including language proficiency),[51,58] educational,[37,59] economic[28,59] and political obstacles need to be overcome. Poverty with associated social and economic deprivation is a leading determinant of poor vaccination coverage in all geographic strata.[28,59]

An economically related topic is that of "guardian problems" which was given by a third of Bophuthatswana mothers as one of the explanations for not being vaccinated.[28] In Praktiseer the length of time that the child was supervised by a child minder after birth was significantly associated with vaccination coverage.[37] The importance of a reliable person looking after the child, especially in the case of working mothers, is emphasised by these two studies. Mothers need a considerable amount of support to raise children, supplement the family income and see to the health needs and vaccination of their offsprings.

New arrivals to cities and the socially deprived are also least likely to be exposed to or even understand health promotion messages and are more likely to be influenced by reports of adverse vaccination reactions.[51]

Lack of health education and information of vaccination and vaccine services were identified in Hillbrow and Bophuthatswana as determinants.[28,39] The related topic of poor maternal educational level was identified in Praktiseer and urban Senegal as an independent determinant of vaccination coverage.[37,59] Educated mothers, where ever they find themselves are better equipped to positively influence the health of their children.[17]

2.3.3 Health Service Failure

Even when all the obstacles to reaching and vaccinating susceptible children are overcome, the quality of the health service may leave much to be desired. The failure of health services to use every available opportunity to vaccinate susceptible children is a major obstacle in the path of achieving disease control.[60,61,62]

Missed opportunities to vaccinate result from poor coordination and training of health staff, and the rift between curative and preventive services which is especially severe in large cities with a multitude of services attending to infants. Recent studies have shown that in Cape Town up to 60% of susceptible children seen at a tertiary hospital were not vaccinated against measles during their visit.[61]

Issues of timing, particularly in the pressured urban environment are important determinants of access to health care. The more days per week a vaccination service is offered, the higher the resulting coverage.[57,60]

The acceptability of the health services to mothers of infants is a crucial and often neglected aspect. Experiences mothers have with vaccination services may be of the most important determinants and include: having been turned away, long duration of waiting time, and hearing reports of children with post-vaccination abscesses.[58]

2.3.4 Political Violence

The disruption of health service delivery in times of political unrest has emerged as a major determinant of primary health care coverage in recent years. In situations of political conflict such as have occurred in neighboring states,[63] Cape Town[64,65] and more recently in Natal and on the Witwatersrand, well-functioning services have been disrupted, with children's health inevitably suffering.

Preventive and promotive care such as antenatal and child health programmes (including home visits and mobile immunisation teams) are usually the first to be discontinued. Basic services and most forms of transport are affected, resulting in delays in vaccine delivery to clinics, health workers not being able to reach their places of work, and mothers and children being denied access to health care.

2.4 Conclusion of Literature Review

In the last decade many developing countries have achieved dramatic improvements in their vaccination coverage levels. Considering the literature reviewed here, the reality is that these countries (including South Africa) are still a long way off from achieving disease control and eventual eradication of the major childhood infectious diseases.

Achieving further sustained increases in vaccination coverage will require better directing of vaccination services and regular comprehensive evaluations of programmes. More energy will have to go into the identification of sub-groups of unvaccinated children and the development of the means to reach them.

Health services, particularly in rapidly expanding urban areas, require detailed information on the determining factors of vaccination coverage if meaningful progress in disease control is to be made in the next decade.

3. **METHOD**

3.1 Study Design

A cross-sectional analytic study design was adopted.

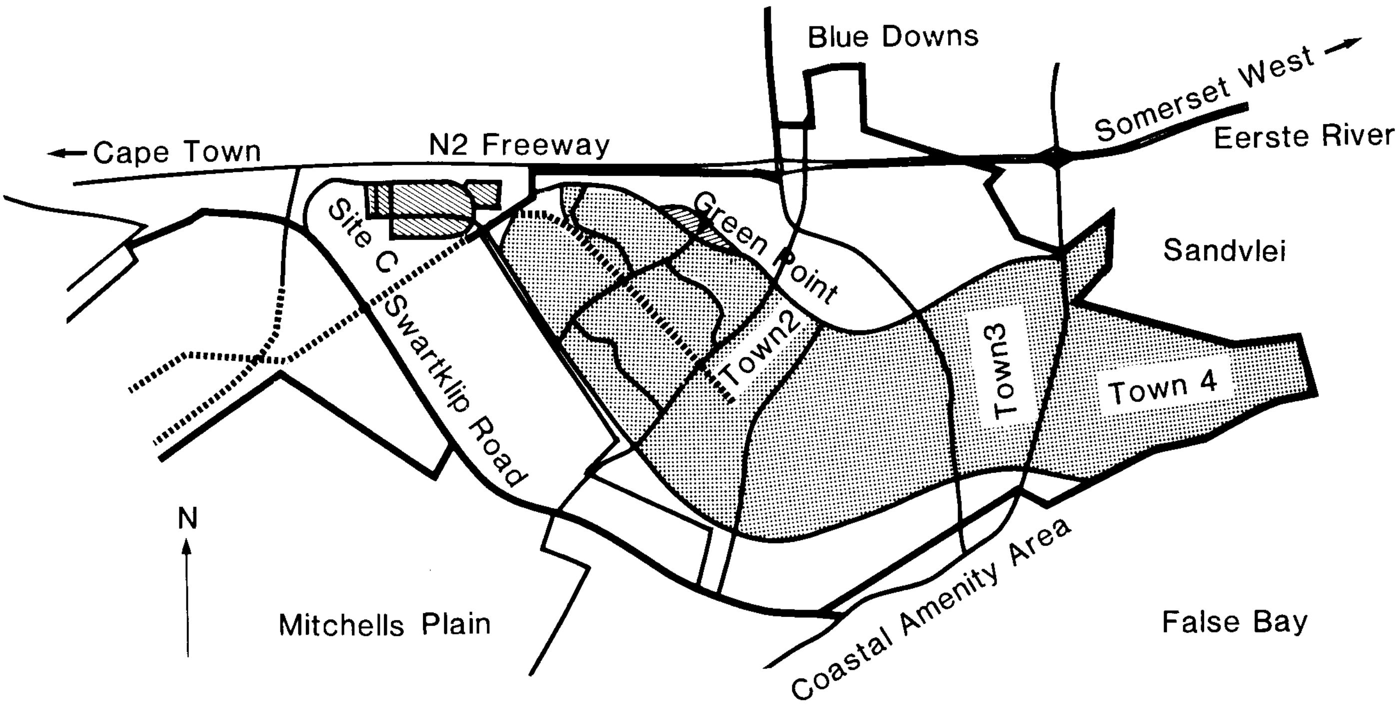
3.2 Study Population

The study was conducted over a 5-day period during February 1989 in Khayelitsha, a peri-urban township of Cape Town (Fig. 1). The target study population consisted of all 12-23 month old children living in Site C and Green Point, two suburbs of Khayelitsha (Fig. 2). Not all the suburbs of Khayelitsha were included in the study because current vaccination coverage data was available for the remaining areas, and the health services requested that Site C and Green Point should be studied as a priority.

Khayelitsha was established in 1983 and expanded to a population of approximately 250 000 to 350 000 by 1989. Because of rapid growth and continuing urbanisation there are no accurate official population figures available. The local authority responsible for health services in Khayelitsha, the Western Cape Regional Services Council (WCRSC) estimated the combined population for Site C and Green Point to be 70 000 in 1989.

Most of the inhabitants of Khayelitsha originate from the rural areas of the Transkei and Ciskei, more than 1000 km

Fig2: Map of Khayelitsha showing the location of site C (containing the New Shanty area) and Green Point in relation to the other sectors (town 1,2,3 &4)



distant. 15% of the population live in formal housing (brick and mortar construction) with reticulated water supply and waterborne sewerage services. The majority of residents live in shacks (corrugated iron, wood and plastic construction) on serviced stands. Because of the rapid influx of new residents to the area and the shortage of serviced stands, many have settled on sites without any services, and in areas not designated for housing.

3.3 Sampling

A stratified multistage cluster sampling technique based on methodology developed by the EPI,[15,66] was used to select 46 clusters of 10 children each. The EPI cluster sampling methodology was developed by the WHO with the objective of providing a standardised, affordable and rapid means of evaluating vaccination coverage throughout the world. Cluster sampling methodology is particularly useful in developing countries where the lack of detailed sampling frames (lists of names and addresses of individual children) precludes the use of simple random sampling.

To obtain a representative vaccination coverage estimate a minimum sample of 210 children (grouped in 30 clusters of 7 children each) is recommended by the EPI (Appendix 8.1). For this reason the EPI surveys are often referred to as "30X7" surveys. This minimum sample will allow for a coverage estimate within 10 percentage points of the true population proportion with 95% confidence.

The "30X7" grouping is generally found to be convenient in the field and 30 clusters is accepted as the minimum needed to obtain a representative sample. More than 30 clusters and larger cluster sizes may however be used to yield increased precision. In the present study a "46X10" sample was selected so that stratum specific vaccination coverage could be estimated and in order to improve the estimate precision to within 5 percentage points of the true population proportion.[15,66]

The EPI methodology used in this study involves the following basic steps: (a) identification and definition of the geographical area of interest; (b) random selection of the 46 sites or "clusters" from within the geographical area; (c) random selection of starting points (households) within each site; (d) selection of 10 children of the appropriate age from within each of the 46 sites.

The study population was divided into three strata (Fig. 2): (i) A planned and ordered area consisting of shacks on site and service residential stands (Site C); (ii) An area within and on the periphery of Site C consisting of unplanned and temporary shacks with no services (New Shanty); and (iii) Temporary shacks in an area two kilometers distant from Site C serving as a transit zone (Green Point).

As no accurate sampling frame existed for the study area, the total number of households within each stratum was determined and mapped in community surveys conducted in the

TABLE 10

SAMPLING FRAME: TOTAL HOUSEHOLDS AND CLUSTER ALLOCATION PER STRATUM

STRATUM	a HOUSES (n)	b BACK-YARD SHACKS (n)	a+b TOTAL (n)	HOUSES (%)	CLUSTERS (n)
Site C proper:					
A	1038	218	1256	7.7	4
B	2314	386	2700	16.5	7
C	2646	441	3087	18.9	9
D	862	144	1006	6.1	3
Sub total	6860	1189	8049	49.2	23
New Shanties:					
E	1000	-	1000	6.1	3
F	400	-	400	2.4	2
G	300	-	300	1.8	1
H	100	-	100	0.6	0
I	50	-	50	0.3	0
J	50	-	50	0.3	0
Sub total	1900	-	1900	11.6	6
Green Point:	6400	-	6400	39.2	17
TOTAL	15160	1189	16349	100	46

seven days immediately prior to the study. The number of households per stratum served as an index of the population size. The 46 sample clusters were allocated proportionally according to the estimated population size of each stratum (Table 10).

Circumstances on the ground, specific to each stratum, dictated the specific method used in selecting clusters and the starting households for individual clusters:

<u>Site C:</u>

The 1985 Western Cape Development Board map (scale 1:2000) was used as the basic sampling frame for Site C. The map has details of every residential stand (numbered sequentially from 1 to 6860) and grouped into sections A, B, C and D (Table 10).

Some households in Site C have backyard shacks on their properties. A survey conducted of 24 randomly selected houses immediately prior to the main study estimated the ratio of backyard shacks to houses to be 1:6. This information was used to derive at a corrected estimate of 8049 dwellings in Site C. This stratum therefore made up 49.2% of the households in the total study population resulting in a proportional allocation of 23 of the 46 sample clusters to Site C (Table 10).

The cluster allocation within Site C was also proportional to the estimated population size of each section (A, B, C,

D) (Table 10). Starting households for each cluster were selected by means of simple random sampling using the numbered stands within each section of Site C as a sampling frame.

New Shanties:

With the help of local community health nurses the New Shanty area of Site C was visited and mapped immediately prior to the study. The New shanty area occupies ground that was originally designated for schools, churches, shops and industrial areas and is found in six geographically distinct sections (E-J) within Site C. Some of the sections lie outside and along the boundary fence of Site C.

The total number of households in the New Shanty area was estimated to be 1900 (11.6% of all households in the study population). Six of the 46 sample clusters were therefore allocated to this stratum (Table 10). The allocation of clusters within this stratum was also proportional to the estimated population size of each section (E,F,G,H,I,J).

Because no official map was available starting households for each cluster were selected by means of a simple random sample, using the hand drawn field maps as a sampling frame.

Green Point:

Green Point was also mapped by field workers prior to the survey and households were found to be arranged in a series of 64 double parallel rows. Each double row consisted of approximately 100 houses giving an estimated total of 6400 houses (39.2% of houses in the study population). The remaining 17 clusters of the sample were allocated to this stratum (Table 10).

Selection of starting households in Green Point was by a systematic sample of 17 rows (sampling interval = 64/17 = 4). Each selected row was then divided into four equal sized sub-units of which one was selected randomly. Starting households were then selected by means of random sampling from within the selected sub-unit.

3.4 Measurements and Fieldwork

In the month preceding the study, local community leaders and headman were informed of the aims of the study, and their cooperation obtained. Before each interview, field workers explained the purpose of the study and obtained consent from respondents.

Trained interviewers, familiar with local language and customs, visited sampled households and administered a structured pre-tested questionnaire (Appendix 8.2) to the child minders of children aged 12 to 23 months. The questionnaire contained questions about the respondent, the child's birth place, date of birth, documented evidence of vaccination, duration of stay in Cape Town and source of information concerning vaccination and recency of visit by community health workers (i.e. lay health workers employed by the WCRSC and deployed in the study area). Child minders were also asked if children had been ill with measles disease in the past.

An additional section of the questionnaire tested the child minders knowledge of the correct constitution of oral rehydration solution. These results do not form part of the objectives of this dissertation and have been reported elsewhere.[67] To improve accuracy of measurement the questionnaire was pre-tested and adjusted on three occasions prior to the final survey: twice at Red Cross Hospital Outpatient Department and once in Site B (Khayelitsha).

Details of birth dates and vaccination history were obtained from children's "Road to Health"cards (RTHC). Only documented proof of vaccination status (as detailed on the RTHC) was accepted as valid information.

The interviewers consisted of eight health workers (5 nurses, 2 health educators and 1 health inspector) employed by the WCRSC Health Department. They were selected because they had not previously worked in the study area and the bias of asking service providers to evaluate their own efforts was therefore minimised. One senior nurse acted as field coordinator and assisted the principal researcher during the five days of the survey.

During three workshops prior to the final survey fieldworkers were carefully trained on all aspects of administering the questionnaire. Role-play techniques and discussion groups were used to standardise interviews and prepare fieldworkers for difficult responses.

Interviewers worked in 4 pairs with a vehicle allocated to each pair. For security and coordination purposes interviewers were in radio contact with the field coordinator. In order to ensure adherence to the sampling procedure fieldworkers were taken to the pre-selected starting points (households) of clusters at the onset of each day of the survey.

Because the survey lasted longer than one day the range of acceptable birth dates for inclusion (children 12-23 months old) shifted one day for each day of the survey. To avoid confusion in this regard a table with the correct birth date range for every day of the survey was supplied to each fieldworker.

After completing the first interview at the starting household within a cluster, fieldworkers continued the survey by selecting the next household whose front door was physically closest to the one just visited.[2] This process of selecting and visiting households was repeated until a total of 10 children (one cluster) of the appropriate age had been identified. Selection bias was minimised by including all children of the appropriate age living in any single household, and excluding nursery schools and creches from the sample.[2]

Locked or empty dwellings that showed signs of being inhabited, or where the child minder was not home, were recorded and revisited once more at a later stage. If no respondent was present on a second visit, the household was assumed to contain a child of the appropriate age, and was included in the sample as representing a non-respondent.

3.5 Analysis

Completed questionnaires were checked for accuracy on a daily basis during the survey. Response data was coded and entered on a mainframe computer (IBM) data base and analysed using SAS statistical software.[68]

Results are given as percentages and proportions. The 95% confidence limits of the vaccination coverage percentages were calculated by taking cluster size and the number of clusters into account in estimating variance.[69] The 95% confidence intervals(CI) are shown in brackets after the percentages.

In the analysis of factors associated with children not having received the measles vaccine, the odds ratio(OR) was used as a measure of strength of association.[70] The 95% confidence intervals on odds ratios were calculated using Cornfield's method.[70]

The age distribution of vaccination for the different vaccines is represented by the median and interquartile range for sample values. The difference between the lower(25th percentile) and the upper(75th percentile) quartiles is called the interquartile range, and contains the central 50% of the data. The median represents the 50th percentile, dividing the sample values in half.[71]

The design effect of cluster sampling was estimated for each vaccine coverage percentage. The design effect is the ratio of the variance of the estimate obtained from the cluster sample (which is a complex sampling design) to the variance of the estimate obtained from a simple random sample of the same size.[69] The main use of the design effect is to appraise the efficiency of the cluster sample. The design effect is therefore a function of the degree of homogeneity within the sample clusters. The more heterogeneous the clusters are within themselves, the more representative the clusters are of the population and the more precise and unbiased the estimate is when using cluster sampling.[69]

The chi-square test was used to test whether associations between variables were statistically significant at the $p < 0.05$ level.[72] The degrees of freedom(df) for each chi-square test are supplied.

Multiple logistic regression analysis was used to identify the predictor variables with the most influence on measles vaccination status.[72] A multiple logistic regression model was fitted to a single binary dependent variable namely the measles vaccination status. The procedure fits a model by a stepwise technique to determine the best predicting variable to be added to the model at any given step.[72,73]

4. RESULTS

4.1 Quality of Information

The total sample consisted of 432 children distributed over 46 clusters giving a response rate of 94%. Cluster size ranged from 6 to 11 with a median of 10 children. The stratified proportional sampling strategy is reflected by the distribution of sample children among the three strata: 36.5% from Green Point, 51.6% from Site C, and 11.9% from the New Shanty area (Table 11). The sample distribution therefore correlates well with the population estimates for each stratum (Table 10).

Invalid and missing responses for individual questions asked during interviews ranged from 1 to 21 (median = 4). The respondent in 75.4% of interviews was the mother of the child. In 69.4% of the sample the child minders could show the child's RTHC to the interviewer for verification of birth dates and vaccination status. A further 21.5% of respondents said that the child did have a RTHC, but that it was not available at the time of the interview (Table 11).

4.2 Demographic Information

4.2.1 Age, sex, maternal education.

Table 11 summarises the demographic information of the study sample. Children were evenly distributed between the

TABLE 11

DEMOGRAPHIC CHARACTERISTICS

		N#	%
1.	Strata: Site C	222	51.6
	Green Point	157	36.5
	New Shanties	51	11.9
2.	Age (months): 12 - <18	226	52.3
	18 - <24	206	47.7
3.	Sex: Female	223	52.1
	Male	205	47.9
4.	Respondent: mother	325	75.4
	other	53	12.3
	aunt	28	6.5
	grandmother	25	5.8
5.	Level of schooling mother:		
	Standard: 0 - 2	77	18.7
	3 - 5	133	32.4
	6 - 10	201	48.9
6.	'Road to Health' Card:		
	yes	297	69.4
	no	39	9.1
	yes, not available	92	21.5
7.	Area of birth: Cape Town	306	72.0
	Transkei	77	18.1
	Ciskei	16	3.7
	Other*	26	6.1
8.	Length of stay in the area:		
	< 6 months	117	27.2
	6 mth - < 1 yr	79	18.4
	≥ 1 yr	234	54.4

* Rest of southern Africa

\# Not all variables total 432 because of non-response to individual questions.

age groups 12 - <18 and 18 - <24 months. 52.1% of children were female (male/female ratio: 0.91). Schooling history served as an indicator of the level of maternal education.

Standard four was the median level of schooling completed by the mothers with 48.9% having completed standard six or higher (Table 11).

4.2.2 Region of Birth

28% of children were not born in Cape Town. Children born outside of Cape Town derived from the following areas: Transkei 64.7% , Ciskei 13.4% and the rest of South Africa 21.8% (Table 11). The mother's level of schooling and the category of respondent were not associated with the region of birth of the children.

4.2.3 Length of Stay

27.2% of children were recent arrivals and resident in Site C and Green Point for less than 6 months (Table 11). The majority of recent arrivals (62.7%) were however not born in Cape Town. No significant difference could be detected in comparing the proportion of new arrivals (less than 6 months residence) resident in each of the three strata (X^2 = 3.7; df = 2; p = 0.159).

4.2.4 Road to Health Card

Cape Town born children were more likely to have a RTHC, compared to children born outside Cape Town (Table 12). Children who had been living in Khayelitsha for longer than a year were also more likely to possess RTHCs compared to children who had lived in the area for less than 6 months (Table 13).

4.2.5 Home Delivery

While 12.5% of all children were reported to have been delivered at home, this figure was strongly associated with the region of birth. The highest home delivery rate was reported among the Transkei births (Table 14).

TABLE 12

ROAD TO HEALTH CARD AVAILABILITY BY REGION OF BIRTH

	Region of birth			
	C T %	Cisk %	Transk %	Other %
RTHC:				
Yes	77.2	43.7	55.2	46.1
No	4.6	18.7	18.4	15.3
Yes, not available	18.0	37.5	26.3	38.4
Total (n)	229	16	76	26

$X^2 = 33.68$; df = 6 ; p = 0.000

Key: RTHC = Road to Health Card
CT = Cape Town
Cisk = Ciskei
Transk = Transkei

TABLE 13

ROAD TO HEALTH CARD AVAILABILITY BY DURATION OF STAY IN GREEN POINT AND SITE C.

	Duration of stay in the area		
	< 6 months %	6 mth - < 1 yr %	≥ 1 yr %
RTHC:			
Yes	51.7	64.5	79.7
No	19.8	8.8	3.8
Yes, not available	28.4	26.5	16.3
Total (n)	116	79	232

$X^2 = 36.98$; df = 4 ; p = 0.000

Key: RTHC = Road to Health Card

TABLE 14

HOME DELIVERY RATE OF CHILDREN BY REGION OF BIRTH

	Proportion delivered at home	
Birth Region	n	%
Cape Town	15/302*	5.0
Transkei	32/77	41.6
Ciskei	2/16	12.5
Rest of Southern Africa	3/26	11.5

* Four values missing in denominator due to non-response.

4.3 Knowledge of Measles Vaccination

More than 80% of child minders reported that they had been informed about the importance of having their children vaccinated against measles (Table 15). Region of birth; area of residence; duration of stay in the area; and home visits by community health workers were all significantly associated with an awareness of the need for vaccination (Table 15).

Child minders of Cape Town births were more likely to have received vaccination information (84.5%) compared to the other regions of birth. The child minders of children living in the New Shanty area of Site C were the least informed about the need for vaccination (56.8%), compared to the other strata. Child minders who had been visited in their homes by a CHW were more likely to have been informed (87.3%) compared to those who were not visited (78.8%). Child minders of recent arrivals (less than six months duration of stay) were least likely (72.6%) to be informed of the need for vaccination (Table 15).

82.9% of child minders said that the source of their information concerning the importance of and need for vaccinating children was one of the Maternal and Child Health clinics (administered by the WCRSC) in the area. 1.7% reported the Day Hospital (administered by the Cape Provincial Administration), 3.2% the radio, 8.4% the hospital, as their source of information on vaccination.

3.8% were informed by other means such as family, friends and word of mouth.

The majority of child minders (86.3%) knew that measles vaccine should be given before the child is exposed to measles in order to prevent disease. Only 2% of child minders said that the vaccine should be administered during an episode of measles disease or during recovery. The remaining 12% were not sure about the importance of giving the vaccine before onset of disease.

4.4 Vaccination Coverage

63.5% (95% confidence interval(CI) 58 - 67) of children had documented proof of vaccination against measles. The coverage rates for all the childhood vaccines is given in Table 16. Only 54.6% of all children were fully vaccinated at the time of the survey.

The accuracy of the timing of vaccination is measured against the target age at which a vaccine is expected to be administered (i.e. according to the vaccination schedule). Vaccines administered soon after birth (BCG, DPT-1, Polio-1) are given very close to the target age. Vaccines scheduled for an older age (measles, Polio-3, DPT-3) showed more variability (in respect of age of vaccination) and were also given progressively later than the prescribed target age. The increasing variability of the timing of vaccination as children grow older is demonstrated by the

TABLE 15

CHILD MINDER'S KNOWLEDGE OF THE NEED FOR MEASLES VACCINATION

	Total (n)	% Informed of need for vaccination
1. Region of birth		
Cape Town	298	84.5
Ciskei	16	62.5
Transkei	77	72.7
Other	24	70.8
All regions	415	80.7
(X^2 = 10.91; 3df; p = 0.012)		
2. Area of residence		
Green Point	149	80.5
Site C	221	85.9
New Shanties	51	56.8
All areas	421	80.5
(X^2 = 22.389; 2df; p = 0.000)		
3. Visit by CHW		
Yes	111	87.3
No	288	78.8
Don't know	20	60.0
All above	419	80.2
(X^2 = 9.093; 2df; p = 0.011)		
4. Duration of stay in the area		
< 6 months	113	72.6
6 mth - < 1 yr	77	83.1
≥ 1 yr	231	83.6
All durations	421	80.5
(X^2 = 6.241; 2df; p = 0.044)		

Key: df = degrees of freedom
CHW = community health worker

widening interquartile age range of vaccination (Table 16).

The age distribution of the time at which measles vaccination was given has a median of 7.3 months. An age range of 2.9-19.7 months for measles vaccination was observed. 6.3% of children were vaccinated before 6 months and 59.7% before 8 months of age. 19.8% of children received their first dose of measles vaccine after 9 months of age (Table 16).

The design effect of cluster sampling for the different vaccine coverage estimates ranged between 1.03 and 1.16 (Table 17).

4.5 Factors Associated with Measles Vaccination Coverage

The univariate analysis of factors associated with measles vaccination coverage is given in Table 18. Home delivery, being born outside of Cape Town, and having lived in the study area for less than six months were all significantly associated with not being vaccinated against measles.

In the multiple logistic regression model, the only variable added was the length of stay in Site C and Green Point. The added variable provided only a marginal contribution to the model (multiple correlation coefficient (R) = 0.180).

TABLE 16

VACCINATION COVERAGE AND AGE OF VACCINATION (n = 432)

	Vaccination coverage		Age of vaccination (months)				
	%	95% CI	Expected	Median	IQR	Percentage in other categories (by month)	
BCG	68.7	63 - 73	0.0	0.03	0.07	91.0% <1	43.0% >3
DPT1	68.0	63 - 72	3.0	3.15	0.83	83.0% <4.5	10.1% >6
Polio 1	67.7		3.0	3.15	0.85	82.7% <4.5	10.2% >6
DPT2	62.3	57 - 67	4.5	4.98	2.00	70.0% <6	9.7% >9
Polio 2	62.0		4.5	4.98	2.02	69.2% <6	8.1% >9
DPT3	57.8	52 - 62	6.0	6.89	2.59	78.2% <9	10.3% >12
Polio 3	57.5		6.0	6.89	2.59	78.1% <9	9.9% >12
Measles	63.5	58 - 67	6.0/9.0*	7.36	2.89	59.7% <8	19.8% >9

Key: IQR = inter quartile range
CI = confidence interval

* First dose of measles vaccine at 6 or 9 months

TABLE 17

DESIGN EFFECT (DE) OF CLUSTER SAMPLING FOR VACCINATION COVERAGE

Vaccine		DE
BCG		1.16
DPT and Polio	1	1.03
	2	1.10
	3	1.07
Measles		1.05

TABLE 18

FACTORS ASSOCIATED WITH MEASLES VACCINATION

Factor		Odds Ratio for not being vaccinated	95% CI*
1. Age:	18-<24 months	1.0	
	12-<18 months	1.4	0.9 - 2.1
2. Maternal education (standard):			
	6-10	1.0	
	3-5	1.2	0.7 - 1.9
	0-2	0.9	0.5 - 1.5
3. Area:	Site C	1.0	
	Green Point	1.2	0.8 - 1.9
	New Shanties	1.5	0.8 - 2.8
4. Delivery:	Institution	1.0	
	Home	2.0	1.1 - 3.6
5. Area of Birth:			
	Cape Town	1.0	
	Outside Cape Town	2.5	1.6 - 3.9
6. Length of stay in the area:			
	≥1 year	1.0	
	6 mth - <1 yr	1.6	0.9 - 2.7
	<6 mth	3.1	1.9 - 4.9

* confidence interval

4.6 Area of Residence

When the three strata were compared, children living in the New Shanty area were shown to have important differences from those living in Site C and Green Point (Table 19). New Shanty children were least likely to have been born in Cape Town (59.2% versus 71.7% in Green Point and 74.8% in Site C) and most likely to be born in Transkei (30.6% versus 14.5% in Green Point and 18.4% in Site C).

Although not statistically significant, a higher proportion of recent arrivals were found living in the New Shanty area (38.2%) as compared to Site C (24.8%) and Green Point (25.6%) (Table 19). The child minders of children in the New Shanty area also had the lowest level of knowledge of the need for measles vaccination (56.8% versus over 80% in the other areas) (Table 15, Table 19) and reported fewer home visits by community health workers (9.8% versus 23.7% in Site C and 35.9% in Green Point)(Table 19).

Although not statistically significant the measles vaccination coverage was the lowest in the New Shanty area (58.4% versus 61.7% in Green Point and 66.1% in Site C) (Table 19). The proportion of children with a history of measles disease was the highest in the New Shanty area (8%). Children in the New Shanty area constituted 12% of the sample, yet accounted for 20% of the children with a history of measles (Table 19).

TABLE 19

AREA OF RESIDENCE

	Region of Birth		Told	Msl/vac	Msl/dis	CHW	<6 mth	Total	
	Cape Town %	Transkei %	%	%	%	%	%	n	%
Green Point	71.7	14.5	80.5	59.8	4.1	35.9	25.6	157	36.5
Site C	74.8	18.4	86	65.3	4.6	23.7	24.8	222	51.6
New Shanties	59.2	30.6	56.9	54.9	8.0	9.8	38.2	51	11.9
X^2	16.1		22.3	2.4	1.2	16.0	3.6		
df	6		2	2	2	4	2		
p	0.01		0.00	0.29	0.53	0.00	0.15		

Key:
Told = told about need to have child vaccination
Msl/dis = measles disease
Msl/vac = measles vaccination coverage
CHW = community health worker home visit
<6 mth = less than 6 months residence
df = degrees of freedom

5. DISCUSSION

5.1 Data Quality

A high overall response rate (94%) was achieved due to the fact that repeat visits were done in cases where no respondent was present during the initial visit. The stratum specific response rate was also satisfactory and reflected the sampling strategy.

The variation in cluster size (6 to 11) was probably due to difficulty experienced in finding children in the very narrow age range of the study population. Interviewers often had to walk long distances from house to house in order to find 12-23 month old children, with the result that certain clusters had fewer than 10 children. Some clusters contained 11 children because all eligible children in the last house in a cluster were included in the sample in an attempt to reduce selection bias.

An even age and sex distribution of sampled children was achieved (Table 11) and serves as an indicator that a representative sample was selected. Despite the fact that the study was conducted during normal working hours a high proportion (75.4%) of respondents were the mothers of sampled children. Data quality for most of the sample can therefore be expected to be of a satisfactory standard. The category of respondent (mother, aunt, grandmother or other) was not related to the region of birth of the children and in this respect data quality for "immigrants" is probably comparable to that of locally born subjects.

Extending the study hours to evenings and weekends would probably have resulted in only a marginally higher maternal response rate. This is in contrast to studies in similar areas where adult males form part of the study population.[43] A high proportion of mothers of young children in this community were at home during the week. Similar maternal response rates were reported by Berry et.al. during a 1990 study in Khayelitsha.[40]

5.2 Demographic Information

Children in the young age group studied (12-23 months) represent a highly mobile group and originated from a remarkably wide range of areas in the previous two years. The majority were born in the Cape Town metropolitan region. Of the 28% born outside Cape Town, 64.7%, came from the Transkei (Table 11), with the remainder made up of children from the Ciskei and areas throughout South Africa. Similar demographic findings were reported in two studies during 1988 and 1990 in Khayelitsha and confirm the urbanising nature of this population.[32,40]

More than a quarter (27.2%) of the children aged 12-23 months had been living in Site C and Green Point for less than six months (Table 11). Only 37.2% of these recent arrivals were born in Cape Town. The majority of recent arrivals to Site C and Green Point therefore derive from outside Cape Town and are not merely from other residential areas within the Cape Town metropolitan region. Most recently arrived children and their mothers or child minders are new to the city environment and will probably face major social, cultural and economic adjustments[59] which could have both beneficial and adverse effects on health.[43]

Upon arrival new immigrants to the study area are taken up by the community and probably live with family or friends, or rent rooms from residents. Even though not a statistically significant finding, the New Shanty areas had the highest proportion of recent migrants. Because uncontrolled ("free") squatting takes place in the New Shanty area and other serviced sites are at a premium, recent arrivals may have a preference for this stratum. This finding may have implications for the tracing of new arrivals by the local health service.

5.3 <u>Road to Health Card (RTHC)</u>

Possession of a RTHC is a good indicator of a child's past access to health care.[74] 69.4% of children had RTHCs available during interviews (Table 11), probably indicating a relatively low past exposure to primary health care. The 30% of children without RTHCs represent a group that were not reached by health services for a variety of reasons.

Cape Town born children probably had easy access to health services from an early age and were therefore more likely to possess a RTHC (77.2%) compared to those born outside the city (55.2% for Transkei births) (Table 12). Health services in the Transkei (where the majority of children who were born outside Cape Town come from) are known to have major deficiencies.[53]

Recent arrivals in Cape Town are less likely to possess a RTHC (51.7%) compared to children living in Cape Town for longer than a year (79.7%)(Table 13). The majority of recent arrivals were born outside Cape Town (62.7%) and originate from areas where health care is known to be inadequate. The low proportion of recent arrivals with RTHCs gives an indication of the difficulty experienced by heath services in tracing new immigrants and assimilating them into the child health care system in Khayelitsha.

5.4 Knowledge of Measles Vaccination

On average a high proportion (>80%) of carers had been informed about the importance of having their children vaccinated (Table 15). Carers of children living in the New Shanty area had a markedly lower awareness of the need for measles vaccination, possibly indicating social isolation and neglect by the health services. Health staff admit that they prefer not to visit the homes of squatters living in areas without basic services such as water and sanitation (N. Coetzee. Unpublished observation: 1989).

Recent arrivals to Cape Town also reported a low exposure to measles vaccination information, therefore supporting the view that health services are experiencing delays in reaching this vulnerable group. A similarly low appreciation for the importance of measles vaccination in child minders of children born outside Cape Town probably results from limited health care coverage in their regions of origin. Some success of the local community health worker programme is indicated by the finding that carers who had been visited in their homes were more likely to know about measles vaccination.

A 1984 study of urban Zulu and Sotho population groups in South Africa found a similar proportion (>74%) of subjects to be aware of vaccination. By contrast the rural population had a significantly lower awareness of vaccination.[75] This supports the view that migrants from disadvantaged rural regions have had poor exposure to health care services. Apart from not knowing about vaccination, it is likely that they are unfamiliar with the complexity of urban health services, and are not identified by the health service upon arrival.

The preventive maternal and child health clinics were shown to be the main source of information on measles vaccination. Curative services (hospitals and day hospitals) were a very poor source of information to the child minder. Recent reports on missed opportunities for vaccination supports the notion that curative services have an under-exploited potential for increasing vaccination coverage in a given area.[62] The low overall vaccination coverage suggests that this point requires urgent investigation locally, particularly given the poor results obtained recently in a Western Cape study.[61]

A greatly underutilised source of information dissemination is the radio. The importance of radio and television were clearly demonstrated in urban Guinea where these media were the most commonly cited sources of information about vaccination.[58] Word of mouth and family and friends served as a poor source of vaccination information, and could therefore be used more effectively in the future. Similar findings were reported from Guinea by Cutts et.al.[58]

Knowledge of child minders concerning the preventive nature of measles vaccination was good in Khayelitsha. Lack of understanding of the importance of vaccination as a preventive measure does not appear to be a barrier to improving vaccination coverage in this population.[76] This is similar to a survey of urban Zulu and Sotho's where >80% believed that vaccination can prevent childhood infections. A much lower proportion of rural inhabitants shared the same belief.[75]

Many black mothers find it necessary to consult additional sources of information on health care for their infants, besides those provided by Western medicine.[77] Because measles is so prevalent in developing regions, some cultures consider it important that children contract measles as an essential part of normal development. Some groups will even encourage measles transmission by washing infants in the bath-water of a known measles patient.[76]

In the rural population of Gazankulu, mothers preferred measles vaccination at the time when a child is sick with measles, rather than when healthy. They believed that the vaccine will help stimulate the eruption of the rash and prevent chest complications and other disease later in life.[76]

Understanding of the traditional beliefs about safeguarding an infant's health may be extremely important in ensuring the success of a vaccination programme.[76,77] Health care workers have to be aware of possible cultural barriers when dealing with rural migrants to Khayelitsha.

5.5 Vaccination Coverage

An urgent need for improving vaccination services in Khayelitsha is indicated by the low proportion (54.6%) of fully vaccinated children. The drop-off in coverage between Polio 1 ; DPT1 and Polio 3 ; DPT3 is 10.2% . This finding is similar to studies in Bulawayo and Harare, but far less than those reported in Taung (Bophuthatswana), Transkei and Lebowa.[28,30,37,38] It is generally accepted that childhood vaccinations which are given earlier in life have higher coverage than those given at an older age. BCG which is given at birth had the highest coverage(68.7%) compared to 57% for DPT3 and Polio-3.

In Malaysia it was clearly demonstrated that the vaccination coverage for DPT-3 is improved when the vaccination schedule is moved one month earlier, and worsened when started later.[78] Mothers are more likely to seek health care in the first few months of the child's life. The peak clinic attendance is usually in the second month of the infants life. By six months approximately 50% of infants have stopped attending health services, and opportunities for vaccinating children are drastically reduced.[78]

For most vaccines the vaccination schedule was adhered to and the age at vaccination was satisfactory. The finding that early vaccines were given closer to the target age and with less variability probably reflects the more frequent contact infants have with the health services in the first 6 months of life.

The policy for measles vaccination in Khayelitsha has been vaccination at six months of age, repeated at nine months. This is in keeping with the recommendations of the Expanded Programme on Immunisation of the World Health Organisation and the South African Measles Workshop recommendations on measles vaccination.[6,79]

In areas of high risk (refugee camps, peri-urban squatter settlements and overcrowded areas) with high morbidity before 9 months of age measles vaccination should begin as soon as possible after the age of six months. Re-vaccination is to take place at 9 months because the low efficacy of standard measles vaccine at six months.[79] In all other "low risk" areas in the developing countries, the EPI recommends that children be vaccinated against measles as soon as possible after 9 months of age.[79] To a large degree the age distribution of measles vaccination in Khayelitsha reflects the policy in this area, with a median of 7.36 months and 70.9% of children having been vaccinated before the age of 9 months of age.

Compliance with the vaccination policy is far from ideal with a large proportion (19.8%) of children not being identified early enough and are receiving their first dose of vaccine only after 9 months of age. In this study information was obtained only on the first dose and age of measles vaccination. No data was collected on the number of children who were vaccinated at both six and nine months against measles.

Also of concern is the small but significant proportion of vaccinations given before the age of 6 months (6.3%). Seroconversion rates of 75-98% are achieved when children are vaccinated with conventional Schwartz vaccine as soon as possible after 9 months of age. Because of the presence of circulating maternal antibodies, significantly lower seroconversion rates are reported if children are vaccinated before 9 months of age.[80,81] A vaccine efficacy rate of 32% has been reported for children immunized before the age of 8 months.[5]

Berry et.al. reported similar findings in a recent study in the New Shanty area of Khayelitsha with a median age at first measles vaccination of 8.2 months.[40] A much higher proportion (12%) of children received their first vaccine before 6 months of age.[40] This information should alert the local health service to the possible threat of reduced vaccine efficacy.

The measles vaccination coverage of 63.5% is surprisingly high considering that the coverage rate for DPT-3, which is also given at six months is 57.8%. A number of measles vaccination campaigns in the 2 years preceding the study may have resulted in improved coverage of measles at this young age.

The true vaccination coverage for all vaccines is possibly higher when considering that 21.5% of the sample reported to have RTHCs that could not be produced during the survey (Table 11). There is however no available objective evidence of this and a further study would be needed to elucidate this assumption.

The narrow range of design effects (Table 17) indicates similar effects of clustering on the proportion of vaccinated children for the various vaccines. A design effect of 1 indicates that there is no clustering of vaccinated children and that the variability is similar to that of a simple random sample. If a tendency exists for vaccinated children to be clustered in the population (neighbors are more similar than those living further apart) the design effect will have a value of greater than 1.[66]

All the design effects have low values (close to 1)(Table 17), indicating that there was minimal clustering of vaccinated children. The sample size was therefore large enough to compensate for the use of cluster sampling methodology(Appendix 8.1). Compared to simple random sampling, the use of cluster sampling in this population was probably an efficient way of obtaining a vaccination coverage estimate with reasonable precision.

5.6 Determinants of Measles Vaccination Coverage

5.6.1 Home Delivery

The odds of not having been vaccinated for home delivered children residing in Khayelitsha relative to children who were delivered at health care institutions is 2.0 (95% CI 1.1 - 3.6). This is of similar magnitude to the findings of a recent study in the same area with an OR of 3.21 (95% CI 1.2 - 8.4)[40] and in Maputo (OR 3.1, $p < 0.05$).[51]

Mothers who delivered at home may have preferred not to use health services. However, a more likely explanation is that health services were inaccessible for a variety of reasons. Children delivered at home have not had the initial contact with health services, even from the antenatal period,[57] form a select group who do not establish an early and sustained relationship with the health service.

These children have lower vaccination coverage rates, irrespective of their place of abode in later life.[1,31,51] In some rural settings with good primary health care services, children delivered at home, often members of resettled groups,[82] also have lower vaccination coverage rates. Home deliveries as a determinant of poor vaccination coverage in urban immigrants is therefore not specific to city areas, but rather a reflection of past access to health services.

The confounding variable in the association between home delivery and low vaccination coverage is the region of birth of the child. 28% of Khayelitsha children in this study were not born in the Cape Town area, of which the majority originated from the Transkei and Ciskei (Table 11). The home delivery rate in Cape Town is known to be less than 5%, in contrast to high rates in Transkei (50%) and Ciskei (20%).[82,83] The regional difference is reflected in the fact that children living in Khayelitsha who were born in Cape Town, Transkei and Ciskei have home delivery rates of 5%, 41.6% and 12.5% respectively (Table 14) - similar to the rates in their regions of origin.

5.6.2 Region of Birth

The odds of not being vaccinated was 2.5 times higher for children born outside Cape Town compared to local births (95% CI 1.6 - 3.9). Children in the New Shanty areas of Khayelitsha had the highest proportion of non - Cape Town births (40%) and the lowest measles vaccination coverage compared to other more established residential areas (Table 19).

Other studies in the urban/peri-urban environment have also shown that children who were not born in the city have lower coverage rates.[39,40,46] In a previous Khayelitsha study the Cape Town born children displayed a 64% measles vaccination coverage compared to 48% for children born outside the city.[32] The poorer access to health services in Transkei and Ciskei may partly explain why children born in these areas had lower vaccine coverage than those born in Cape Town.

An interesting finding is that measles vaccination coverage of children living in Khayelitsha who were born in Transkei (50.1%) is similar to a recent EPI coverage estimate for measles vaccination in the Transkei (47.1%).[30] This suggests that migrant children are probably not a select group in terms of vaccination coverage.

5.6.3 Length of Stay

The odds of not being vaccinated for children resident for less than 6 months was 3.1 (95% CI 1.9 - 4.9) compared to more permanent residents. The lack of social integration and low socioeconomic status experienced by new urban migrants is contributory to their children having lower vaccination coverage.[59]

Kearney et.al. reported that children who have recently migrated to Khayelitsha from rural areas have significantly lower vaccination coverage rates (39%) compared to those resident for more than 4 months (58%).[32] A period of residency of more than 6 months in the New Shanty area was also significantly associated with improving vaccination status during a 1990 study.[40] These findings are consistent with reports from Maputo where the odds ratio for not being vaccinated for children resident in the city for less than a year was 4.7 ($p < 0.01$).[51]

There is obvious confounding in the relationship between the above three variables (home delivery; place of birth; length of stay) as determinants of measles vaccination. The individual contribution of each of these variables is difficult to unravel. Using multiple logistic regression analysis length of stay in Khayelitsha was the factor explaining most variation in measles vaccination coverage. The low multiple correlation coefficient ($R = 0.180$) in this instance indicates that apart from length of stay, there are other as yet unexplained variables that serve as determinants of measles vaccination.

5.6.4 Education

New "immigrants" who have poor education and are often culturally isolated have great difficulty in using the health services effectively.[51,59] In contrast to studies in similar peri-urban,[51,59] and in rural areas[37] the educational level of mothers in Khayelitsha was not associated with the vaccination status of their children.

Selection factors operating in the urbanisation process may have been important in determining the high overall level of maternal education in the study population.[43] Though no-one would venture to say that education is irrelevant to the issue, it certainly seems to be more complicated than at first glance.

Recent migrants are also least likely to be exposed to (Table 15) or even understand health promotion messages[51] and are more likely to be influenced by reports of adverse vaccination reactions.[51]

5.6.5 Area of Residence

Those living in the unplanned and unserviced New Shanty areas of Khayelitsha have the highest incidence of measles, poorest knowledge of vaccination, and least home visits by community health workers. Although not statistically significant the vaccination coverage is lowest in the New Shanty area, probably as a result of the high proportion of non-Cape Town births (mostly Transkei) and recent migrants.

Because of the stratified study design it was possible to identify children living in the New Shanty area as being a high priority group for health service intervention. If broader geographical boundaries were used in this study, this high risk group would probably not have been identified.

5.6.6 Age

Age at time of interview was not significantly associated with vaccination coverage (Table 18). Children had completed their vaccination schedule by the age of 12 months and therefore the coverage in the two age categories (12 - <18 months and 18 - <24 months) showed no meaningful difference.

The age of the child at the time of vaccination is however important for vaccination coverage. The drop off in coverage with increasing age at which vaccines are to be administered was clearly demonstrated (table 16), and has implications for improving vaccination coverage.

6. LIMITATIONS

6.1 Cross-sectional study design

Only children living in Khayelitsha at the time of the survey were included in the study. Because of the high population mobility and migration patterns children not present at that time may have had a markedly different vaccination status from those who were included in the survey.[43]

The high rate of influx to the study area severely limits the value of a single cross-sectional study. Repeat surveys at regular intervals are indicated to establish a more representative view of the study population over time.[43]

The timing of the survey may have been an important factor in determining the likelihood of certain groups being included. A survey conducted on weekends and in the late afternoons may have yielded more representative results. Had the study taken place during different season, the population composition may have differed due to migratory labour practices.[43]

The cross-sectional study design does also not allow for a temporal sequence of events to be established. It is therefore not possible to distinguish cause from effect when interpreting the various factors associated with low vaccination coverage.[43,58]

6.2 Validation

Vaccination histories could only be validated by referring to documented proof of vaccination. It is conceivable that vaccination records(RTHCs) had certain inaccuracies and omissions which could have affected the accuracy of the vaccination coverage estimates.

Inaccuracies in birth dates as recorded on the RTHCs may have resulted in incorrect inclusion of children.

6.3 Reliability

No assessment of data reliability was undertaken. A repeat survey of a sub-sample would have given an indication of possible measurement error and data accuracy.[84]

6.4 Statistical analysis

The EPI cluster sampling methodology was developed with the sole purpose of establishing a reliable vaccination coverage figure (a simple proportion) and has limitations when used in analytical studies. Standard statistical tests used in analytic questions (Chi-square, confidence intervals, linear and logistic regression) assume that simple random sampling or unbiased systematic sampling has been carried out.[15] The second stage of EPI sampling(selection of individuals) does not qualify as simple random sampling and has some inherent biases.

The use of EPI derived samples to test for associations and population variance can therefore be problematic. Adjustments that may result in more precise estimates include:

a) Felligi has proposed adjustments to the Chi-square test that may considerably improve accuracy.[40]

b) The "bootstrap" technique, which involves numerous computer based resampling procedures (with replacement) from the original sample data.[85]

6.5 First Stage Sampling

The selection of starting households (first stage sampling) in two of the strata may have been biased.[15] In the New Shanty area random sampling of houses was dependent on the accuracy of hand drawn field maps. Aerial photographs were not available for validation of these maps.

In Site C bias may have been introduced in that backyard shacks (identified in the small survey preceding the main survey) were not included in the sampling frame for random selection of starting points. Backyard shacks were however included in the population estimates and in the second stage of sampling.

6.6 Second Stage Sampling

The EPI sampling methodology does not use simple random sampling in selecting individual children (second stage sampling), but relies on the field worker moving along to "the next closest house". Cluster households are therefore spatially related and their occupants may have a number of factors in common including access to vaccination services with resultant similar vaccination status.[15] This may have resulted in higher or lower vaccination coverage estimates, depending on the location of the starting household.

The selection of successive households during stage two, creates further opportunity for bias. It is left to the discretion of the interviewer to decide which household is the closest to the one just visited. The interviewers preferences may result in some houses not being visited and these may then be underrepresented.[15]

Even though an attempt was made to revisit locked houses where children were known to be living, the selection process may have favoured unemployed mothers, who are more likely to be at home during working hours. The exclusion of nursery schools and creches may have introduced an additional bias. These children may belong to a higher socioeconomic group with higher vaccination coverage than children of unemployed mothers.

6.7 Age Range

Birth dates that comply with an age range of 12-23 months were calculated separately for each of the five days of the survey. The birth dates for the age range 12-23 months therefore shifted by one day for each day of the survey. This error of 4 days was unavoidable, but should be kept in mind in comparing these results to other surveys.

6.8 Vaccination Coverage Data

No data was collected on the second dose of measles vaccine. Compliance with the measles vaccination policy in this population (vaccination at 6 and at 9 months) could therefore not be evaluated.

Because only documented proof of vaccination was accepted, true vaccination coverage may have been underestimated. It is possible that a significant proportion of children without RTHCs at the time of the survey may have been vaccinated, and would therefore not have been included in the coverage estimates.

All documented vaccinations at the time of the survey were included in vaccination coverage estimates. It is possible that some of these vaccinations may have been ineffective because of being given at too young an age, or too soon after a preceding dose. For this reason some authors have specified certain age ranges for inclusion as valid vaccinations in calculating coverage estimates.[37,86]

A commonly accepted schedule for inclusion of vaccinations as valid is as follows: BCG given at any age; first dose of DPT/polio given not before 2 months and 21 days of age, and subsequent doses not less than 28 days apart; first dose of measles vaccine given not before 6 months, and the second dose not before 9 months of age. Applying these (or similar) exclusion criteria to the study may have resulted in lower vaccination coverage estimates.

Because of a relatively small sample size the stratum specific vaccination coverage estimates will lack the precision of those for the total sample. Vaccination coverage estimates for each of the three strata are however unbiased with high validity and remain useful in studying the differences between strata as long as their limitations are understood.

7. CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Even though only a minimum estimate, the overall vaccination coverage and the coverage for individual vaccines was found to be inadequate in the section of Khayelitsha under study. Bearing in mind the potentially serious consequences that could result, the most disturbing finding was a measles vaccination coverage rate of 63.5%. In addition to low coverage, the low median age of measles vaccination should raise concern about vaccine efficacy in this population.

A number of determinants of vaccination coverage were identified and include the region of birth and the setting (home of hospital) in which children were delivered. A short duration of stay of children (< 6 months) in Khayelitsha was the variable best explaining vaccination coverage status. These determinants indicate that the incompletely vaccinated children (and their mothers) make up a highly mobile group who have recently migrated to the city from underserved rural areas. The majority of recent arrivals to Khayelitsha were born outside Cape Town and originated from the rural areas of Transkei and Ciskei.

Not only did new arrivals have lower vaccination status, they also were less likely to be in possession of RTHCs compared to more permanent residents. This finding supports the notion that immigrants to Khayelitsha originate from areas with poor primary health care service delivery. To further impact on their poor start, newly settled residents from outside Cape Town receive less exposure to vaccination promotion messages. These findings point to the inability of the health services to identify and assimilate newly arrived children into the health care delivery system in Khayelitsha.

The stratification of the study population was useful in highlighting potential differences between groups and in directing future interventions. The New Shanty stratum was identified as a neglected area requiring particular attention by the health services in future. Children in this stratum probably constitute the lower socioeconomic group, who have been unable to secure a permanent residential stand. Children with incomplete vaccinations are however not confined to the New Shanty area and are found dispersed throughout the other strata.

This study has important implications for the future control of childhood vaccine preventable diseases under conditions of urbanisation. The solution to the attainment of the EPI goal of disease control lies in a more effective and directed use of existing services. Spending scarce resources on reaching high risk groups (such as new arrivals) is likely to be a sound investment for ensuring sustained high vaccination coverage in sprawling peri-urban settlements.

7.2 Recommendations

7.2.1 Measurements

The quantitative epidemiological methodology used was useful in evaluating the technical details of vaccination coverage, but was of limited value in answering operations research questions and in identifying more subtle determinants of vaccination. In future more use could be made of qualitative social science research methods to complement quantitative techniques.[58]

7.2.2 Sampling

Vaccination coverage data derived by EPI sampling methods may lack sufficient geographic resolution, and be too costly and time consuming to be of practical use to service managers within large urban settings. The need exists for a quicker, easier and more practical sampling method to be used by all levels of health workers in rapidly urbanising populations.

To this end the use of lot quality assurance (LQA) sampling should be considered in future vaccination coverage evaluations.[87] An area is subdivided into subunits or "lots" which are then allocated to individual health workers. Each lot is sampled randomly to determine whether or not vaccination coverage is below a predetermined target level. Health workers need not complete the survey of their lot in one day and can incorporate this work into their regular routine activities in the area. Results are quickly and regularly available and resources can be directed at specific high risk areas without having to conduct a special survey. The cumulative result of all these lots collected over the service area can be used to estimate a vaccination coverage rate for the whole area.[88]

7.2.3 Age Range

The narrow age range (12-23 months) of the study population resulted in many households having to be excluded because they did not have children of the correct age present. This resulted in greater financial expenditure on field work.

The vaccination histories of children 12-23 months old represent the efforts of health services over the preceding 2 years. In order for these coverage estimates to remain current, it is necessary to repeat the survey every year or two. A wider age range for the study population (6 months - 5 years) would reduce costs by making it much easier to find children of the correct age. Surveys could then be repeated at less frequent intervals.

7.2.4 Routine Vaccination Data

Because of limited resources regular EPI coverage surveys can often not be undertaken by local and district health authorities. Future EPI coverage surveys should include in their protocols a comparison with estimates derived from routinely collected vaccination information. Vaccination coverage estimates obtained from EPI surveys could be used to validate coverage estimates derived from routine data.

To calculate coverage in children under 1 year of age from routine information the number of vaccinations given in a year are divided by the number of infants. Various biases in the numerator and denominator of this calculation lead to deviations from EPI survey derived estimates. These estimates are often either consistently lower[89] or higher[86] than those obtained from sample surveys. Once the extent of these biases have been quantified by means of EPI sample survey estimates, routine data can be used in a meaningful way. Relying solely on coverage estimates from routine data is however not recommended.[6]

7.2.5 Vaccine Delivery

The sustained functioning of a metropolitan vaccination liaison group is essential for solving problems, improving patient access, coordinating services, up-dating staff and promoting vaccination knowledge.[90] It is essential that representatives from the community are included. Such a group would also coordinate the activities of governmental and non-governmental organisations. Both have an important role to play in improving vaccine delivery, and are able to compliment each other.[91]

In future greater community participation is called for. Community leaders could assist in identifying recent migrants to the area and directing them to the health worker. Community health workers should also be used more effectively to channel groups at risk to the health services and enhancing compliance with the vaccination schedule and by improving the follow-up of defaulters.[92] In Maputo the success of such an approach is illustrated by the fact that new arrivals to the city are not a risk group for low coverage as they are specifically identified by health workers and channeled to clinics for vaccination.[51]

Rural areas with low coverage, such as Transkei,[30] serve as a constant source of unvaccinated children to the city. The problems of improving rural coverage[28,30,93] need to be addressed together with urban problems on a regional basis, if control is to be achieved in the future.

One of the most important areas for improving coverage is that of preventing missed opportunities for vaccination and the spreading of vaccination information.[51,61] Reluctance of staff to vaccinate even on a "non-immunisation day" or not opening a vial of vaccine for one or two children, are still common practice. Refusal to vaccinate sick children, especially in curative settings, has resulted in many infants being denied one of the few available opportunities to receive protection. Health services for children should be organised with the aim of reducing all barriers to vaccination, and for the convenience of mothers, not of service providers.

The artificial differentiation between curative and preventive care has to be eliminated as a matter of urgency.[33,61] Immunisation should therefore be available at every session and also outside of normal working hours. Restricting vaccination to one or two clinic sessions a week has prevented many areas from achieving adequate and sustained coverage.[33,61]

Other aspects of improving access to vaccination services (distance, time, cultural, economic, attitude, waiting times) have to be assessed in future studies.

A finer disaggregation of routine health data for the urban population is needed in order to identify high risk groups with low coverage.[91] Vaccination programmes should then be targeted at such risk groups: children delivered at home, born outside the city and recently settled migrants. The population of the New Shanty area was identified as a group that needs to be monitored more closely in future.

Underutilised opportunities for improving community knowledge of vaccination and vaccination services do exist. Greater use should be made of radio and television as a medium for dissemination of vaccination information. The community health workers should also give greater attention to disseminating the vaccination message.

Hospitals and clinics have had only a marginal role in promoting vaccinations in the past. This is an area that needs urgent attention if any measure of long term success is to be achieved in this population. Curative services could also play a major role in promoting the use of RTHCs, which would then have a number of benefits, including improved vaccination coverage.

Further advances in vaccine technology such as the introduction of the Edmonston - Zagreb measles vaccine to be given at 4-6 months of age[94] will undoubtedly improve herd immunity at an earlier age, and possibly also overall vaccination coverage. Younger children are more likely to attend health services than those older than 9 months, thus increasing the probability of being vaccinated. Consideration should also be given to changing the existing schedule to vaccinate children at a younger age with polio and DPT antigens.

Policy implementation needs to be addressed. Significant proportions of children are receiving their first dose of measles vaccine either before 6 months or only after 9 months. Training and supervision of field staff are essential in this regard.

7.2.6 Vaccine Efficacy

Because of the significant proportion of children who were vaccinated against measles under 6 months of age, and not having information on the proportion who received a second dose at 9 months, the efficacy of measles vaccine in this population is questionable. Future studies should include data on the second dose of measles vaccine and investigations of vaccine efficacy.

8. APPENDIX

8.1 EPI Cluster Sampling Theory[15,66,71]

The EPI method treats vaccination status as a binomial variable. Individuals in a population are classified as being either vaccinated or not vaccinated. For binomial variables the formula for random sample size calculation is given as:

$$n = (z^2pq)/d^2$$

n: sample size

d: required precision(the degree to which data centres around the population proportion)

z: confidence limits of the survey result

p: the expected proportion who are vaccinated

q: proportion of persons in population who are not vaccinated (1-p)

Using this formula the WHO calculated the "30X7" sample of 210 individuals as follows: (i) the precision of the estimate is to lie within 10 percentage points of the population proportion($d = 0.1$); (ii) confidence limits of 95% would be required ($z = 1.96$); (iii) p and q were both assigned the value 0.5 because n is then maximised. Using the above details a simple random sample of 96 was calculated.

Because of the lack of accurate sampling frames in developing countries and the high cost of random sampling the EPI decided that cluster sampling would be more appropriate. There is often a tendency for individuals who live in close proximity to share a variety of characteristics. Therefore cluster sampling may result in a loss of precision.

The design effect (see analysis section for explanation) of a cluster sample is usually less than 2, meaning that the cluster sample size need seldom be more than double that of a simple random sample to compensate for loss of precision. A sample size of 192(twice 96) was therefore calculated.

A minimum of 30 clusters were required to permit statistical theory, based on the normal distribution, to be used in analysis. Finally then, to permit an equal number of 30 clusters a sample size of 210 was agreed upon. Experience dictated that a cluster size of seven children is practical in the field.[15,66,71]

8.2 QUESTIONNAIRE

RSC CHILD HEALTH PROJECT

Code No. ....

Cluster No. ....

Address ....

Fieldworker ....

Date: ....

*Fill In One Form For Every Child In House Older Than 12 Months and Younger Than 24 Months.

1. What is the child's AGE? ....years ....months

2. Who is answering for this child?

Mother	1
Grandmother	2
Brother/sister	3
Neighbour	4
Other (specify)	5

3. Name of child (first name only):....................

4. Sex of child?

Female	Male
1	2

5. What is the highest standard the mother completed at school? ....

6. Where did the mother give birth to the child ?

home	1
clinic	2
day hospital (MOU)	3
hospital	4
other (specify)	5

7. Was the child born in Cape Town?

Yes	Nc
1	2

If yes,

Name suburb in Cape Town where mother was living at that time ....

If no,

Where was mother living when the child was born ?

Ciskei	1
Transkei	2
other.............	3

Name of: town/village.............

district ....

8. How long has child been living in Site C/Green Point?

less than 1 week	1
1 week - 1 month	2
2 weeks - 6 months	3
7 months - 1 year	4
more than 1 year	5

9. Does child have a preschool card?

Yes	No	Yes, but not available
1	2	3

10. What is the child's date of birth?

D	D	M	M	Y	Y

11. Source of birth date?

Preschool card	1
Birth Certificate	2
Memory	3
Other (specify)	4

12. From preschool card, mark what immunizations child received and the dates:

		Received yes	Received no	D	D	M	M	Y	Y
BCG									
DPT	1								
	2								
	3								
Polio	1								
	2								
	3								
Measles									

Where was the measles immunization given (from card)?

....

13. If no preschool card, ask: "Has child ever been immunized against measles?".

Yes	No	Don't know
1	2	3

If yes,

Where was the immunization given? ....

14. Where you told about the need to have your child immunized against measles?

Yes	No
1	2

If yes,

Who told you?

mother	1
grand mother	2
neighbour	3
friends	4
radio	5
magazine/newspaper	6
day hospital	7
hospital	8
clinic	9
other (specify)	10

15. When should the measles injection be given ?

At time when child is ill with measles	1
When the child recovers from measles	2
Before the child gets measles	3
Do not know	4
Other (specify)	5

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