A vaccination survey using the EPI methodology to evaluate the impact of a child health outreach programme in an urban area of South Africa

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A community-based survey of the vaccination status of children aged 12–23 months was conducted to evaluate the impact of a child health outreach programme on vaccination coverage in Alexandra township, South Africa. The EPI cluster sampling technique was adapted for this purpose. The sample size, including the number of clusters and the number of units per cluster, was increased to permit stratification of the data and comparison of the results with those obtained in a study conducted prior to the introduction of the outreach services in 1988.

At the time of the survey interview, 67% of the children were fully vaccinated (78% against measles) and by 1 year of age, 58% were fully vaccinated (69% against measles). The increase in coverage since the introduction of the programme was statistically significant only for measles (Student's t-test, P <0.01). A total of 75% of children living in formal dwellings, compared with 51% living in informal dwellings, were fully vaccinated by interview (Fisher's exact test, two tailed, P <0.0001). Mothers from informal dwellings had a 1.88 times greater chance of not knowing about the outreach services (P <0.001). Children whose mothers knew where vaccinations were given, attended postnatal clinics, used the outreach services, possessed a road-to-health card from the Alexandra Health Centre, and who resided in a formal dwelling all had a higher chance of being vaccinated.

Introduction

Alexandra township is situated 15 km from the centre of Johannesburg. Estimates of its current population range from 150 000 to 250 000, a threefold increase since the census of 1985 (1). Approximately 33% of the population live in informal dwellings or shelters, 15% in new developments, 8% in three large single-sex hostels, and the remainder in old houses. The already poor socioeconomic conditions have been aggravated by rapid urbanization and its associated problems, unemployment, and the 3-year state-of-emergency in South Africa.¹ Inadequately maintained sewage, sporadic refuse removal, the absence of storm-water drainage, and overcrowding in the township are predisposing factors for infectious disease and concomitant poor nutritional status.

Most of the health services for the community are provided by Alexandra Health Centre and University Clinic (AHC), a privately funded facility. In its efforts to provide comprehensive health care to all the people, AHC is attempting to create a model for health care for the urban poor (2). Curative services, including 24-hour emergency and maternity services, and preventive and promotive services are provided. An outreach service is also operated by AHC. A total of 17 general practitioners provide primarily curative care, a number of traditional healers are active in the area, and a state clinic provides services to deal with tuberculosis, chronic psychiatric problems, and some vaccinations.

Vaccination is provided by both AHC and the state health clinic according to the following schedule: BCG and monovalent oral poliovirus vaccine at birth, diphtheria–pertussis–tetanus (DPT) and oral trivalent poliovirus vaccine 1, 2, and 3 at 3, 4 1/2 and 6 months of age, respectively; and measles vaccine at 9 months of age. Administration of monovalent

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⁴ Alexandra Health Centre and University Clinic annual report, 1990.
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poliovirus vaccine at birth was introduced in South Africa in February 1989 and at AHC in October 1989 (3). As in most developing countries, there is still a considerable amount of morbidity and mortality from vaccine-preventable diseases in South Africa (4). In 1989 there were 18 123 notifications of measles, including 322 deaths, and 12 notifications of poliomyelitis (5). It is generally accepted that in South Africa measles is underreported (6).

In Alexandra there was an outbreak of poliomyelitis in May 1986, during which six cases were isolated, and there has been an outbreak of measles each year in spring. During the 1987 measles outbreak, 85 cases were reported including five deaths within a 5-month period. Notifications of measles, diphtheria, and poliomyelitis over the period 1986–91 are shown in Table 1. Following the outbreaks of poliomyelitis in 1986 and of measles in 1987, mass vaccination campaigns were conducted in Alexandra township. Because of the recurrence of the outbreaks each year and the limited efficacy of the mass campaigns (7, 8), late in 1988 vaccination services at AHC were revised. Previously, vaccinations were only provided by the well baby clinic on three mornings a week at the health centre and once a week at the state clinic.

Thus the child health outreach programme was introduced in October 1988, based on the evidence from previous surveys that children living further from AHC were less likely to be vaccinated and that the services provided by the well baby clinic were not accessible to the majority of the community (9, 10). Each weekday morning from 08 h 30 to 11 h 30 a team of nurses went to one of five fixed points in the community to provide a well baby service, including vaccination. In consultation with AHC, the state health clinic also established five outreach points. These services ran concurrently with the well baby clinic at AHC. The target of the programme was a 75% coverage rate for measles vaccine by the end of 1989.

A vaccination coverage survey was conducted in 1988, prior to introducing the outreach programme, to collect baseline data. Only 61% of children aged 12–23 months were fully vaccinated by the time of interview (67% against measles), while 50% were fully vaccinated by 1 year of age (56% against measles) (9). In order to evaluate the impact of the outreach programme on vaccination coverage, we decided to repeat the vaccination survey in early 1990 using the same sampling frame and methodology as in the previous survey (9).

Table 1: Notifications of infectious diseases in Alexandra township, 1986–91

<table>
<thead>
<tr>
<th>Year</th>
<th>Measles</th>
<th>Diphtheria</th>
<th>Poliomyelitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>35</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>1987</td>
<td>92</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1988</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1989</td>
<td>41</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1990</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1991</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Although pertussis is a notifiable disease, it is rarely notified in South Africa.

Population and methods

The study population included all children aged 12–23 months who were resident within the municipal boundaries of Alexandra, but including also an informal settlement on the northern boundary of the township. The sample size was 450 and the sampling unit was a dwelling with a child in the required age group. The sampling strategy was similar to that used by the WHO Expanded Programme on Immunization (EPI) (11). Although this methodology calls for 30 clusters of seven units, we increased it to 45 clusters of 10 units to allow for stratification of the data into formal and informal dwellings and to permit comparison with the 1988 study when 45 clusters of seven units were surveyed.

Examination of an aerial photograph of Alexandra taken in 1988 and field inspection and counting of dwellings revealed that each block in the old section of the township contained approximately 120–150 dwellings. Each cluster consisted of one block. In informal settlements and the new developments, a field researcher counted the dwellings, and a cluster was created for each 120–150 dwellings. A total of 45 clusters were randomly selected from the 108 that had been defined. The starting dwelling in each cluster was randomly selected, and the interviewers moved to the adjacent dwelling according to well-defined rules until 10 children in the required age group were found. Data were collected using a standard schedule. The dates of vaccination were recorded from the child’s road-to-health (RTH) card. Children whose mothers did not have an RTH card were recorded as not vaccinated. The mothers or permanent guardians of all children were interviewed and a structured interview was used to identify variables associated with vaccination status. Information was also collected on the type of dwelling, including criteria for assessing it as an informal dwelling or as part of a new development.

Twelve interviewers were selected from AHC staff; most of them were acquainted with the methodology through having participated in the 1988...
for the survey. For the purpose of training the interviewers and to test the interview schedule and the methodology, we conducted a field pilot study in a cluster not selected for the survey.

The names of all mothers of children aged 12–23 months who were identified but who were not present at the time of the interview were obtained from other members of the family or from neighbours, and two further attempts were made to interview them at their convenience. If a mother or guardian had two children aged 12–23 months, only the first-born was included in the study. If the interviewer was unable to find 10 mothers with children aged 12–23 months in a particular cluster, the difference was not made up from another cluster.

A resident was defined as any mother or guardian who had spent at least one night in Alexandra during the previous month. A guardian was defined as any person over 18 years of age who cared for any child aged 12–23 months for most of the time. When a guardian was interviewed, she was only asked questions about the RTH card. A residence was defined as an informal dwelling if it had no street number, if it was not built primarily of bricks, or if the interviewer assessed it to be one. Repeatability checks were performed on 41 of the interview schedules to check the inter-observer repeatability of the data collected. The survey was conducted in March and April 1990.

Because of the complex nature of the sampling procedure and the need to stratify the data, the analysis required a number of specific procedures. All data were analysed using SAS software (12). Descriptive statistics and a bootstrap procedure (13–16) were used to determine the rate of vaccination coverage, with 95% confidence intervals for each vaccine and for the complete schedule, as follows: within 28 days of the due date; within 42 days of the due date; by 1 year of age; and at the time of the survey. In the bootstrap procedure repeated random samples with replacement were drawn, and estimates were calculated from each sample and stored. This process was repeated 100 times. From the univariate distribution of the stored estimates the relevant statistics were calculated.

Student’s t-test was used to compare the rate of vaccination by 1 year of age and at the time of the interview for the 1988 and the present surveys. Fisher’s exact (two-tailed) test was used to compare the vaccination rates for children from formal dwellings with those for children from informal dwellings. The odds of the following were calculated for a child who was associated with a particular variable, compared with a child not associated with that variable: being vaccinated on time, by 1 year of age, and at the time of the interview. Because of the cluster sampling method, the bootstrap procedure was used to estimate the variable in question and the Catmod procedure was used to obtain the odds ratio; this procedure analyses models where the independent variable is categorical and takes into account other predictor variables (12). The kappa (κ) statistic was calculated to determine the agreement between answers obtained in the survey with the repeatability study (17); values >0.75 represent excellent agreement beyond chance, while values <0.4 may be taken to represent poor agreement beyond chance (17).

Results

The mothers or guardians of 426 children aged 12–23 months were interviewed. The response rate was 100%. In four clusters less than 10 children in the required age group were identified. Five interviews had to be excluded; in two cases the full date of birth was not known and in three cases the age of the child was not within the required range. Thus the denominators in the study were 421 children, 421 mothers and guardians, and 396 (94%) mothers only. The κ statistics for various variables are shown in Table 2. Of the dwellings visited, 32% were assessed as being informal.

The ages of mothers and guardians ranged from 15 to 62 years (mean, 28 years). A total of 6% were teenagers and 6% were guardians. Of the children, 51% were male and 49% were female (mean age, 18.1 months). A total of 97% of the mothers attended an antenatal clinic on at least two occasions, 64% at AHC; 88% of mothers attended a postnatal clinic with their children, 63% at AHC. The mothers or guardians had RTH cards for 88% of the children. A total of 10% of mothers reported that the card was elsewhere, 2% (7 mothers) said that they had lost the card, and 0.2% (1 mother) stated that they had never had a card. Of those who had cards, 80% had AHC cards, 5% had cards from the state health clinic, while 15% had a card issued elsewhere.

<table>
<thead>
<tr>
<th>Questions relating to:</th>
<th>Kappa statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge about where vaccinations are given</td>
<td>0.93 (0.57–1.00)</td>
</tr>
<tr>
<td>Attendance at a postnatal clinic</td>
<td>0.80 (0.55–1.00)</td>
</tr>
<tr>
<td>Use of outreach services</td>
<td>0.95 (0.64–1.00)</td>
</tr>
<tr>
<td>Information on road-to-health cards</td>
<td>0.91 (0.62–1.00)</td>
</tr>
</tbody>
</table>

*P <0.0001.

b Figures in parentheses are the 95% confidence intervals.
The mothers of 91% of children knew at least one place where vaccinations were given in Alexandra. A total of 68% knew that vaccinations were given at AHC, but only 59% were aware that vaccinations were given at mobile outreach points; the latter were used by 59% of the mothers.

The vaccination coverage rates, excluding poliovirus vaccine given at birth, are presented in Table 3. Except for coverage with BCG, the coverage for each vaccine increased uniformly with the age of the child. A total of 5% of children received a dose of monovalent poliovirus vaccine at birth.

The vaccination rates reported in the 1988 survey are compared with those found in the present survey also in Table 3. Only the rates for coverage with measles vaccine by 1 year and at the time of the interview exhibited a statistically significant increase in the 1990 survey (Student’s t-test, \( P = 0.0081 \) and \( P <0.01 \), respectively). A total of 75% of children living in formal dwellings, compared with 51% of those living in informal dwellings, were fully vaccinated at the time of the interview (Fisher’s exact test, two-tailed, \( P <0.0001 \)). The odds of a child who was associated with a particular variable, compared with a child not associated with that variable, being vaccinated on time, by 1 year of age, and at interview are shown in Table 4. The children of mothers who knew where vaccinations were given, attended postnatal clinics, used the outreach services, possessed an RTH card issued by AHC, and resided in a formal dwelling had a higher chance of being vaccinated. Mothers from informal dwellings had a 1.88 times greater chance of not knowing about the outreach services (\( P <0.001 \)).

### Discussion

#### Limitations of the study

Since we were unable to obtain a recent aerial photograph of Alexandra township, a complete sampling frame for the study area was not available. Clusters were delineated on the basis of their visual impression during field inspection and on the interpretation of an aerial photograph taken in 1988.

The sampling method was based on the assumption that the average number of persons per household was uniform across clusters. However, during the survey it became apparent that, on average, more people were living in informal dwellings, too few clusters may have been allocated to the informal settlements and too many to the new developments. This could have resulted in an estimated vaccination coverage that was higher than the true level. Since the only vaccination details included in the study were obtained from the RTH cards, the “true” vaccination coverage is likely to be an underestimate (18, 20).

#### Effectiveness of the outreach service

Comparison of the present study with that conducted prior to the introduction of the outreach services indicates that the increase in coverage for the complete vaccination schedule was not statistically significant. Coverage for measles vaccine did, however, show a statistically significant increase. The overall percentage increase in coverage since 1988 is encouraging, and the decrease in the number of cases of measles, diphtheria, poliomyelitis, and pertussis over the past 3 years may be an indication of the

### Table 3: Vaccination coverage in Alexandra township in the 1990 and 1988 surveys

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Within 28 days of due date</th>
<th>Within 42 days of due date</th>
<th>By 1 year of age</th>
<th>At interview</th>
<th>% increase since 1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCG</td>
<td>81 (76–85) (^d)</td>
<td>81 (77–85)</td>
<td>81 (77–86)</td>
<td>77</td>
<td>82 (77–86)</td>
</tr>
<tr>
<td>DPT1+P1</td>
<td>71 (66–76)</td>
<td>73 (68–78)</td>
<td>82 (77–86)</td>
<td>75</td>
<td>84 (79–88)</td>
</tr>
<tr>
<td>DPT2+P2</td>
<td>56 (51–61)</td>
<td>60 (55–66)</td>
<td>78 (74–83)</td>
<td>69</td>
<td>81 (76–85)</td>
</tr>
<tr>
<td>DPT3+P3</td>
<td>47 (42–51)</td>
<td>53 (48–58)</td>
<td>71 (66–76)</td>
<td>62</td>
<td>75 (70–80)</td>
</tr>
<tr>
<td>Measles</td>
<td>54 (49–59)</td>
<td>60 (55–65)</td>
<td>69(^e)(64–74)</td>
<td>56</td>
<td>78(^e)(73–83)</td>
</tr>
<tr>
<td>All</td>
<td>12 (8–15)</td>
<td>13 (9–17)</td>
<td>58 (54–63)</td>
<td>50</td>
<td>67 (61–71)</td>
</tr>
</tbody>
</table>

\(^a\) The number of children covered in the 1990 and 1988 surveys were 421 and 315, respectively.

\(^b\) DPT1–3 = diphtheria–pertussis–tetanus; P1–P3 = poliovirus vaccine.

\(^c\) Data are for 1990.

\(^d\) Figures in parentheses are the 95% confidence intervals.

\(^e\) Statistically significant, \( P <0.0081 \).

\(^f\) Statistically significant, \( P <0.01 \).
Table 4: Vaccination survey in Alexandra township, 1990: odds ratios and confidence intervals for factors associated with higher vaccination coverage

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccinated on time</td>
<td></td>
</tr>
<tr>
<td>Knew where vaccinations given</td>
<td>25.70 (16.65–36.91)</td>
</tr>
<tr>
<td>Attended PNC at AHC</td>
<td>4.40 (2.47–10.23)</td>
</tr>
<tr>
<td>Attended PNC</td>
<td>3.87 (1.81–15.95)</td>
</tr>
<tr>
<td>Used the outreach services</td>
<td>3.66 (2.07–5.81)</td>
</tr>
<tr>
<td>Possessed an RTH card from AHC</td>
<td>2.73 (1.49–6.70)</td>
</tr>
<tr>
<td>Resided in a formal dwelling</td>
<td>2.30 (1.32–3.92)</td>
</tr>
<tr>
<td>Vaccinated by age 1 year</td>
<td></td>
</tr>
<tr>
<td>Resided in a formal dwelling</td>
<td>9.84 (4.53–17.22)</td>
</tr>
<tr>
<td>Attended PNC</td>
<td>2.40 (1.02–4.51)</td>
</tr>
<tr>
<td>Knew where vaccinations given</td>
<td>1.70 (0.80–3.11)</td>
</tr>
<tr>
<td>Vaccinated at interview</td>
<td></td>
</tr>
<tr>
<td>Knew where vaccinations given</td>
<td>24.98 (15.95–36.69)</td>
</tr>
<tr>
<td>Used the outreach services</td>
<td>2.58 (1.48–4.48)</td>
</tr>
<tr>
<td>Attended PNC at AHC</td>
<td>2.32 (1.31–4.99)</td>
</tr>
<tr>
<td>Possessed an RTH card from AHC</td>
<td>2.28 (1.33–4.46)</td>
</tr>
</tbody>
</table>

- P <0.0002.
- PNC = postnatal clinic; AHC = Alexandra Health Centre; RTH card = road to health card.
- Within 42 days of due date.
- Figures in parentheses are the 95% confidence intervals.

clinical relevance of the outreach services (5). Monovalent type 1 poliovirus vaccine given at birth was only introduced in South Africa in February 1989 and this may account for the low coverage rate (5%). The children included in the survey were born between March 1988 and April 1989.

It is very important to note that only 51% of children from informal dwellings, as opposed to 75% from formal dwellings, were fully vaccinated at interview. During the past 2 years there has been a large influx of women and children into Alexandra, primarily into informal dwellings. In fact, vaccination coverage might have decreased had it not been for the outreach services (19). However, our findings suggest that provision of services to these areas, where there is a constant influx of people, is still inadequate and needs strengthening.

As in the 1988 survey, the “on time” coverage rates were very low, indicating that the services provided were inefficient. Nevertheless, the methodology used to measure the “on time” rates needs to be taken into account; if the first vaccination in a series, e.g., DPT is not on time, none of the following vaccinations in that series will be. The “on time” coverage rates for BCG, DPT-1, poliovirus vaccine 1, and measles are better indicators of efficiency. The drop-out rates are similar to those found in other areas in southern Africa (20).

Our survey shows that vaccination status was associated with the utilization of other primary health care services, especially those provided at AHC. Approximately 60% of mothers made use of the latter services. This could indicate that 30–40% of the community, a proportion similar to the percentage of informal dwellings, where vaccination coverage was poor, are not being properly reached by AHC and are unaware of these services. This was confirmed by the finding that mothers of children in informal dwellings had a 1.88 times greater chance of not knowing about the outreach services and that children from some of these areas, although they lived opposite AHC, had some of the worst vaccination coverages.

Conclusions

It is essential that vaccination services in the study area be revised and made more accessible to those sections of the community who had poor coverage. Outreach services should be extended to cover all areas of Alexandra, and specifically informal dwellings and settlements. A dedicated and well-motivated team should be assigned to the outreach service to knock literally on each door in areas with informal dwellings to promote and educate about vaccination and child health.

Provision of information about services is essential in areas where there is a constant influx of people. Thus, continual and extensive advertising of outreach services should be encouraged at every opportunity, including the use of loud hailers announcing when the team will arrive, placing posters in shops and public places, and by word of mouth through community organizations.

Reports from developing countries and studies in southern Africa have revealed that a significant proportion of children leave health facilities without being fully vaccinated for their age (21, 22). Every available opportunity should be used to vaccinate and educate on child health, even if this occurs after normal working hours. The use of RTH cards should be promoted at all times.

Further investigations should be carried out to quantify the extent of missed opportunities for vaccination, while investigations should also be made to identify factors associated with poor utilization of primary health care services, and specifically those mothers from informal dwellings and those who did not have RTH cards. Although such investigations would involve the use of complex methods and analysis, which are expensive in terms of money and time (23), the information gained would be invaluable for planning and revising services.
Vaccination surveys should be conducted at regular intervals in the study area. This will monitor the progress in coverage and identify the risk groups, and at the same time maintain an incentive for continued improvement.

Acknowledgements

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Résumé

Utilisation de la méthodologie du PEV pour évaluer l’impact d’un programme de services périphériques de santé infantile sur la couverture vaccinale dans une zone urbaine d’Afrique du Sud

Une enquête à base communautaire a été entreprise pour évaluer l’impact d’un programme de services périphériques de soins de santé infantile sur la couverture vaccinale des enfants de 12 à 23 mois dans la circonscription d’Alexandra, en Afrique du Sud. La technique d’échantillonnage par grappes du PEV a été adaptée à cette fin. La taille des échantillons, y compris le nombre de grappes et le nombre d’unités par grappe, a été augmentée pour permettre la stratification des données en vue de leur analyse statistique et pour pouvoir comparer les résultats avec ceux d’une enquête effectuée en 1988, soit avant l’introduction des services de santé périphériques.

Au moment de l’enquête, 67% des enfants étaient complètement vaccinés (78% contre la rougeole). Parmi les enfants âgés d’un an, 58% étaient complètement vaccinés et 69% l’étaient contre la rougeole. L’amélioration de la couverture vaccinale depuis le début du programme n’a été statistiquement significative que pour la rougeole (test t de Student, P <0.01).

Parmi les enfants vivant dans des habitations permanentes, 75% étaient vaccinés, contre 51% de ceux qui vivaient dans des logements de fortune (test exact de Fisher, distribution bilatérale, P <0.0001). La probabilité de ne jamais avoir entendu parler des services périphériques était 1,88 fois plus grande pour les mères vivant dans des logements de fortune (P <0.001). Cela tend à confirmer que l’information et l’accessibilité aux services sont insuffisantes et doivent être améliorées dans ces zones où de nouveaux arrivants ne cessent d’affluer.

Les enfants dont la mère savait où avaient lieu les séances de vaccination, fréquentait une clinique de soins post-nataux, avait recours aux services périphériques, possédait la fiche “Le chemin de la santé” fournie par le centre de santé d’Alexandra, ou résidait dans une habitation permanente avaient tous de meilleures chances d’être vaccinés.

Pour améliorer les services, il est recommandé de profiter de toutes les occasions de vaccination et d’éduquer, d’éliminer les occasions manquées de vaccination au centre de santé d’Alexandra, d’entreprendre une campagne dynamique d’information, d’étendre les services périphériques à l’ensemble de la communauté et d’accorder une attention particulière aux enfants vivant dans des logements de fortune.

References

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