The Provision of Measles Vaccine for an Urban Population

B. DICK

SUMMARY

The implications of the unavailability of free measles vaccine for an urban community are examined. Measles mortality and morbidity statistics for Cape Town are reviewed, and the Coloureds and Blacks are shown to be the population groups at highest risk. A case is made for vaccination of those members of the population between 9 months and 5 years of age who are at risk, and for including measles vaccination in the third visit of a modified immunisation schedule. A simple cost benefit analysis strongly favours vaccination.


In South Africa, measles has had devastating effects on various sections of the population. Severe outbreaks occurred in the Cape (1807) and notable epidemics affected the Hottentot community (1852), and women and children during the South African War (1899 - 1901). As recently as 1960, over 1 000 Black mineworkers required hospitalisation for measles, and the serious nature of this disease in a Black reserve has been well documented by Leary. At the present time, reports by Medical Officers of Health indicate that measles is an important cause of infantile mortality and morbidity in the low socio-economic South African urban communities.

Many countries, developed and developing, have found measles to be sufficiently important to warrant institution of nationwide vaccination programmes.

In South Africa, measles vaccine is not provided free to local authorities by the Department of Health. Certain local authorities have, through their own initiative and resources, obtained supplies of vaccine for inclusion in their immunisation services. However, this policy has been implemented only in the larger cities where the prohibitive costs of the vaccine are more easily borne.

It was therefore decided to examine the extent of measles and its complications in an urban South African community, and to explore some of the implications of the unavailability of free measles vaccine for the local authority concerned.

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AIMS

The aims of the study were:
1. To define mortality rates for measles and its complications in the Black, Coloured, White and Asian populations living in the Cape Town municipal area, to determine 'high-risk' groups and to assess the need for immunisation.
2. To estimate the impact of measles and its complications on these priority groups, quantitatively and qualitatively.
3. To determine the optimal age for vaccination of the high-risk groups, and to ascertain the practicability of including measles vaccination in the existing immunisation schedule.
4. To estimate the cost of introducing routine measles immunisation for the groups at risk within the defined area, to compare these with (2) above, and to evaluate these findings, draw conclusions and make recommendations.

PATIENTS AND METHOD

Definition of Criteria

The term 'measles complication' is employed to cover all problems associated with measles that are sufficiently serious to warrant admission to hospital. Children who contracted measles while in hospital for other reasons are not included, since they were not hospitalised for measles.

The Cape Town Municipality constitutes the 'defined area'. Its boundaries encompass 282 km² of predominantly urban dwellings, although adjacent territory is also included. All four broadly-defined ethnic groups are represented in the municipality and there is a wide range of socio-economic standards and living conditions. The estimated total population for 1973 was 770 780. This consisted of 427 740 (55.5%) Coloureds, 242 600 (31.5%) Whites, 90 250 (11.7%) Blacks and 10 190 (1.3%) Asians. Because they form a small percentage of the total population, the Asian group has been excluded from all analysis.

Method of Collecting Data

Mortality figures, population estimates, treatment and vaccination costs were obtained from the Cape Town City Council Health Department. The age breakdown from 1960 - 1973 was based on the 1960 and 1970 South African
census reports. Unfortunately, these reports cover the Cape Town magisterial district and not the municipality. The population structures were not, however, considered to be markedly different. Corrective factors have been employed to give gradual increments to the total population during the 10-year periods between census reports. No such alterations were implemented for possible changes in the population structure during these decennaries.

Neither measles, nor its complications, is notifiable in South Africa. Therefore, the only easy method of assessing the extent of the problems related to measles was by a retrospective study of hospital admissions. For this purpose, data from the City Hospital for Infectious Diseases and the Red Cross War Memorial Children’s Hospital were reviewed for the calendar year 1973.

The City Hospital for Infectious Diseases admits acute infectious diseases from the Cape Town Municipality and surrounding areas of the Western Cape. Only patients from the defined area have been considered in the present study. The majority of patients with measles who are admitted to this hospital are referred by local hospitals or general practitioners; some patients arrive without reference and are admitted if the medical staff consider that this is necessary.

The Red Cross War Memorial Children’s Hospital admits a small number of children with measles, who are in extremis and need emergency treatment. Survivors are subsequently transferred to the City Hospital for Infectious Diseases. In order to make some assessment of the extent of post-measles complications, the total number of patients with ‘bronchopneumonia’ admitted to the Red Cross War Memorial Children’s Hospital from the defined area were examined. These results were only included in the calculation of the over-all costs of measles and its complications.

RESULTS

Mortality Rates

The number of deaths associated with measles and its complications was obtained for the years 1963 - 1973 for the total population residing within the defined area. These deaths and their age distribution are summarised in Table I. The majority of deaths from measles occur in the group under 5 years of age, and only 4 deaths (0.9%) occurred in children over 5 years of age during the period surveyed. From the deaths in this age group for the period 1960 - 1973, age-specific mortality rates were calculated. These results are represented diagramatically in Fig. 1. Although the White population is not completely spared from the effects of measles, the highest age-specific mortality rates occurred in the Black and Coloured groups, and consequently these were regarded as the population at high risk.

The City Hospital for Infectious Diseases

The total admissions from the defined area to the City Hospital for Infectious Diseases (1950 - 1973) for measles, diphtheria, poliomyelitis and pertussis, are represented in Fig. 2. All races and age groups are included.

In 1973 there were 357 admissions from the defined area to the City Hospital for Infectious Diseases for measles and its complications, and the distribution of these cases for race and sex is summarised in Table II. Of the 357 admissions, there were 246 (68.9%) Coloured, 99 (27.7%) Black and 12 (3.4%) White children. There were 27 deaths, 21 (77.8%) Coloured and 6 (22.2%) Black.

An age distribution for the admissions from the Black and Coloured populations is given in Fig. 3. Only patients less than 5 years of age are included (there were a further two admissions at 6 years, and one each at 11 and 13 years of age). The numbers of admissions in each age group are represented as a cumulative percentage distribution of the total admissions. It may be seen that over 90% of the cases of measles occurred in children less than 3 years old, 50% before 15 months and 25% before 10 months of age.

The 345 Black and Coloured patients accounted for 5 907 days of hospitalisation (mean 17, range 1 - 114), 814 X-ray examinations (mean 2, range 1 - 13) and 913 individual courses of antibiotics (mean 3, range 1 - 7); 271 (78.6%) patients received 2 or more antibiotics and 174 (50.4%) received 3 or more.

In 1973, the over-all cost/patient/day at the City Hospital for Infectious Diseases was R11.77. This is an average expenditure and does not allow for the patients with measles requiring more expensive therapeutic regimens or for the greater demand on the hospital’s staff and equipment, when this is compared with tuberculotic admissions for example. With a total number of 5 907 patient days of hospitalisation as a consequence of measles and its complications, the over-all cost of measles to the City Hospital for Infectious Diseases was R69 112.

The Red Cross War Memorial Children’s Hospital

In 1973, 20 children with a diagnosis of measles were admitted to the Red Cross War Memorial Children’s Hospital; 19 of them (96%) were Coloured or Black, and 6
Fig. 1. Age-specific measles mortality rates for Black, Coloured and White children less than 5 years of age per 100,000 population, for the Cape Town municipal area, 1963 to 1973. (*Only deaths from January to July are available for 1972.)

Fig. 2. Total admissions for measles, poliomyelitis, diphtheria and pertussis to the City Hospital for Infectious Diseases, from the Cape Town municipal area, 1950 to 1973.

**TABLE II. TOTAL MEASLES ADMISSIONS AND DEATHS (INCLUDING DEATHS AS A PERCENTAGE OF TOTAL ADMISSIONS) FOR THE CITY HOSPITAL FOR INFECTIOUS DISEASES FROM THE CAPE TOWN MUNICIPAL AREA FOR THE CALENDAR YEAR 1973**

<table>
<thead>
<tr>
<th></th>
<th>Coloured</th>
<th></th>
<th>Black</th>
<th></th>
<th>White</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Admissions</td>
<td>Deaths</td>
<td>Admissions</td>
<td>Deaths</td>
<td>Admissions</td>
</tr>
<tr>
<td>Male</td>
<td>126</td>
<td>10 (7.9%)</td>
<td>51</td>
<td>4 (7.8%)</td>
<td>7</td>
</tr>
<tr>
<td>Female</td>
<td>120</td>
<td>11 (9.2%)</td>
<td>48</td>
<td>2 (4.2%)</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>246</td>
<td>21 (8.5%)</td>
<td>99</td>
<td>6 (6.1%)</td>
<td>12</td>
</tr>
</tbody>
</table>
Fig. 3. Black and Coloured measles admissions from 0 to 60 months of age as a cumulative percentage distribution of total Black and Coloured measles admissions from the Cape Town municipal area to the City Hospital for Infectious Diseases for the calendar year 1973.

(31.6%) died. In view of this very high figure, it should be noted that these deaths occurred in 2 children admitted in extremis, in 2 patients with unassociated medical complications (acute hepatic failure and cytotoxic therapy), and in 2 children who had been transferred from the City Hospital for Infectious Diseases with complications which required intensive therapy. These 19 patients were responsible for 329 days (mean 17, range 1 - 59) of hospitalisation.

Of a total of 191 cases of 'bronchopneumonia - unspecified' admitted during 1973, 28 (14.7%) had been diagnosed as suffering from 'post-measles bronchopneumonia', and of these, 6 (21.4%) died (1 death was associated with malnutrition). A total of 455 patient days (mean 16, range 1 - 43) of hospitalisation were taken up by this group of patients. The findings from the Red Cross War Memorial Children's Hospital are summarised in Table III.

In 1973, the cost/patient/day at the Red Cross War Memorial Children's Hospital was R24.29. Admissions to this hospital of patients with measles and its complications, accounted for a total of 784 patient days of hospitalisation, and a calculated expenditure of R19.043.

The over-all estimated cost of hospitalisation for measles and its complications for the Coloured and Black populations from the defined area during 1973 was calculated to be R88.155 and the data are summarised in Table IV.

**Vaccination**

With the development of further attenuated strains of measles virus, a vaccine became available which provided adequate seroconversion and protection with an acceptably small number of accompanying reactions and an anticipated durable, if not life-long, immunity. After having decided on a satisfactory vaccine, it is important to ascertain the age groups to be vaccinated.

**Lower age limit:** Recommendations have been made that the administration of live-virus measles vaccine should be delayed until children are over 12 months old. If this policy were to be implemented for the population at risk in the present study, then 45% of the children would have been excluded from the protection afforded by vaccination (see Fig. 3).

It has been suggested that in South Africa the best time to administer measles vaccine is 'just before 6 months of age'. Immunisation of this age group would not only necessitate a booster at a later date, but would also give unsatisfactory protection to an unknown number of vaccinated children. If, however, vaccination is delayed until new susceptibles are over 8 months of age, then satisfactory protection and effective control could be expected. The children less than 9 months of age (17% in the present study) would be indirectly protected, since the infectious pool of measles in the community would be greatly decreased, and their chances of coming into contact with the live virus would be correspondingly diminished.

**Upper age limit:** Without either serological data or a reporting system for measles, the age above which the majority of children have already suffered from natural measles is not easily determined. Whether the age distribution of hospital admissions reflects the spread of measles in the community is not certain, but the results of the present study indicate that measles and its complications are only serious enough to require admission to hospital of Coloured and Black children under 5 years of age (Fig. 3).

**Table III. Total Coloured and Black Admissions to the Red Cross War Memorial Children's Hospital for Measles and Post-Measles Bronchopneumonia from the Cape Town Municipal Area for the Calendar Year 1973**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Coloured</th>
<th></th>
<th>Black</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Admissions</td>
<td>Deaths</td>
<td>Admissions</td>
<td>Deaths</td>
<td>Admissions</td>
</tr>
<tr>
<td>Measles</td>
<td>12</td>
<td>4 (33.3%)</td>
<td>7</td>
<td>2 (28.6%)</td>
<td>19</td>
</tr>
<tr>
<td>Post-measles bronchopneumonia</td>
<td>19</td>
<td>2 (10.5%)</td>
<td>9</td>
<td>4 (44.4%)</td>
<td>28</td>
</tr>
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</table>
TABLE IV. COST ASSESSMENT OF BLACK AND COLOURED ADMISSIONS ASSOCIATED WITH MEASLES AND POST-MEASLES BRONCHOPNEUMONIA FROM THE CAPE TOWN MUNICIPAL AREA, TO THE CITY HOSPITAL FOR INFECTIOUS DISEASES AND THE RED CROSS WAR MEMORIAL CHILDREN'S HOSPITAL FOR 1973

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Diagnosis</th>
<th>Number of admissions</th>
<th>Number of patient days</th>
<th>Cost/patient day (in rands)</th>
<th>Total cost (in rands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hospital for Infectious</td>
<td>Measles</td>
<td>345</td>
<td>5 907</td>
<td>11.77</td>
<td>69 112</td>
</tr>
<tr>
<td>Diseases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Cross War Memorial</td>
<td>Measles</td>
<td>19</td>
<td>329</td>
<td>24.29</td>
<td>7 991</td>
</tr>
<tr>
<td>Children's Hospital</td>
<td>Post-measles broncho-</td>
<td>28</td>
<td>455</td>
<td>24.29</td>
<td>11 052</td>
</tr>
<tr>
<td></td>
<td>pneumonia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>392</td>
<td>6 691</td>
<td>60.35</td>
<td>88 155</td>
</tr>
</tbody>
</table>

The population to be vaccinated has therefore been restricted to children in the high-risk group between 9 months and 5 years of age. In an initial 'blanket' immunisation programme, the number of children who would have required vaccination in 1973 is calculated to be 82 028 (total notified births, April 1968 to March 1973 inclusive (86 444), minus associated deaths during this period (4 416) = 82 028 children). This figure does not account for inward and outward population movements for this age group in the defined area.

If a 'blanket' measles immunisation programme had been completed before 1973, the total number of new susceptibles requiring vaccination during this year would have consisted of 18 644 children (total notified births, April 1972 to March 1973 inclusive). The number of deaths in this group have not been subtracted because this information is not available.

In 1973 the over-all cost of the Cape Town City Health Department vaccination team, excluding expenditure on vaccines, was R45 680. During this year, 211 342 individual vaccinations were performed, giving a calculated cost of 22 cents/vaccination. At the present time further attenuated live-virus measles vaccine is obtainable in South Africa for large-scale use at 80 cents/dose. The over-all cost in 1973 of a single measles vaccination, including administration, is therefore calculated to be R1.02.

For the 'blanket' immunisation of 82 028 children, the over-all expenditure on measles vaccination in 1973 would have been R83 669. If an extensive programme for measles vaccination had been implemented before 1973, the cost of vaccinating the 18 644 new susceptibles during this year would have been R19 017. With a minimal total hospitalisation cost for measles and its complications of R88 155, the total saving in 1973 would have been R4 486 for a 'blanket' immunisation programme and R69 138 for follow-up vaccination. The over-all cost assessment is summarised in Table V.

TABLE V. COMPARATIVE COST ANALYSIS OF HOSPITALISATION, 'BLANKET' PROGRAMME AND VACCINATION OF NEW SUSCEPTIBLES FOR MEASLES IN COLOURED AND BLACK CHILDREN FROM THE DEFINED AREA DURING 1973

<table>
<thead>
<tr>
<th>Policy</th>
<th>Number of children</th>
<th>Total cost (in rands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalisation</td>
<td>392</td>
<td>88 155</td>
</tr>
<tr>
<td>'Blanket' vaccination programme</td>
<td>82 733</td>
<td>83 669</td>
</tr>
<tr>
<td>Vaccination of new susceptibles</td>
<td>18 644</td>
<td>19 017</td>
</tr>
</tbody>
</table>

vaccines would be satisfactorily administered and measles vaccination could be included at the third visit. This would obviate any additional burden for the immunisation team and another visit to the clinic by the mother.

In 1973 there was a total of 18 243 children eligible for triple antigen and poliomyelitis vaccination (births from October 1972 - September 1973). In the 0 to 1-year age group there were 16 988 (93.1%) first visits, 16 044 (87.9%) second visits and 15 030 (82.4%) third visits for vaccination. Although this gradual fall-off might be increased if the intervals separating visits were to be lengthened, there is no reason why a portion of the yearly R69 138 saving should not be utilised for a more intensive follow-up of defaulters.

DISCUSSION

Mortality

That mortality rates for measles among the Coloured and Black children are still high, must give some cause for concern. Many epidemiological factors associated with measles have been identified. There is extensive evidence which relates the outcome of measles infection in certain countries with socio-economic and environmental factors and it is likely that these are responsible for the severity of this disease in Cape Town. Influx from other localities may be a factor associated with the particularly high measles mortality rate in the Black children; although they ostensibly come from addresses within the defined area, they may not strictly be resident.
In view of the socio-economic influences on the natural history of measles, it is worth emphasising that all general measures, both medical and other, aimed at improving the lot of the underprivileged classes, will help to decrease the severity of this disease. However, as a policy decision, vaccination would appear to be a more feasible proposition for reducing the severity and ultimate cost of the morbidity and mortality associated with measles than plans to attempt immediate general improvements in living standards.

Morbidity

Fig. 2 shows a rapidly increasing demand for the hospitalisation of patients with measles and its complications. The causes of this recent rise in the number of admissions are not clear. Among the factors involved may be an increasing population, greater awareness of the potential severity of measles and its complications and an expansion of existing medical services in the community, with an associated increase in the expectations and standards of medical care, as well as a diminishing trend in the other childhood infectious diseases, which provides more potential hospital accommodation for measles and a concomitant easing of criteria for admission.

It is somewhat surprising that so few White children required hospitalisation. Although it is possible that the number has been affected by vaccination obtained privately, it is more likely that it reflects the better socio-economic conditions and more extensive medical services available to this group, which would make treatment in the home a more practical proposition. What is evident, however, is that the Black and Coloured children are not admitted to hospital because of the adverse conditions for domiciliary treatment. The average stay in hospital and the large quantities of antibiotics and X-ray examinations involved, indicate that hospitalisation has been needed because of the serious nature of the infection.

Vaccination

The benefits of measles vaccination are now widely accepted. However, there is still much discussion concerning the lower age limit for effective vaccination. For the high-risk population in the present study, seroconversion studies in children less than 12 months old will be necessary before this situation can be clarified. Likewise, without further epidemiological surveys, the age above which vaccination is unnecessary will remain uncertain.

Work in South Africa has suggested that lower titre vaccine may provide adequate protection against measles. Although it may be necessary to dilute the vaccine under conditions where it is in short supply, the possibility has not been considered in the present study where a recommendation has been made to vaccinate children less than 12 months old. Because of the potential interference with antibody production in this group by residual maternal antibodies, the maximal immunogenic stimulus should be provided.

There are two aspects of measles vaccine and its administration that could, however, lower the over-all cost of a vaccination programme. Firstly, where large numbers of children require vaccination, the use of jet injectors, rather than the standard syringe and needle, may be both cheaper and more rapid. Secondly, if a large-scale measles vaccination programme were to be started, adequate quantities of vaccine could be produced in South Africa, which might possibly decrease expenditure.

Cost Benefit Analysis

The estimated cost of hospitalising patients with measles and its complications (see Table V) is the absolute minimal expenditure. This does not include admissions to hospitals other than the City Hospital for Infectious Diseases and the Red Cross War Memorial Children’s Hospital, and it takes into account only one group of post-measles complications in the latter. No attempt has been made to include the expense involved in managing measles complications in outpatient departments and clinics, nor have the deaths been translated into economic terms.

The direct costs and benefits, which include expenditure on hospitalisation, vaccination and lives saved, are fairly easily calculated. However, indirect costs and benefits are less readily quantifiable. These include loss of future earnings, savings in the time of doctors and nurses which could be utilised for other medical problems, the time and energy involved in maintaining adequate surveillance, the hospital admissions that occur despite an intensive vaccination programme, and the prevention of suffering and disruption of family life.

The saving of lives and avoidance of hospitalisation should be sufficient reason to implement preventive measures against measles; because vaccination would also obviate much of the cost to the health service, there can be few arguments for further delays in the drawing up of a measles vaccination programme. In view of the potential benefits to be gained from immunisation, the Cape Town City Council sponsored a pilot measles vaccination programme in 1974. It is understood that it is the intention of the State Department of Health to provide free measles vaccine and the present study consolidates the urgency of this proposed action.

CONCLUSION

If research carried out in other countries is relevant for the population residing in the Cape Town Municipality, measles vaccine, if effectively stored and administered, will provide adequate and long-lasting protection against measles, with few associated adverse reactions. It should therefore be possible to control measles and its associated morbidity and mortality by offering this vaccine freely to the community. In view of the limited resources of all health budgets, high-risk groups must be defined to ensure that available benefits are offered to the most severely affected members of the population. In the present study,
this high-risk group consisted of Black and Coloured children under 5 years of age. Since vaccination is likely to be unsatisfactory in children less than 9 months old, a case is made for the immunisation against measles of all members of the population at risk between 9 months and 5 years of age.

The benefits of a vaccination programme have been discussed from both economic and humanitarian viewpoints, and the analysis strongly favours vaccination. Present immunisation schedules have been reviewed, and it is suggested that if the regimen were to be changed to immunisation at 3, 4, and 9 months, then measles vaccine could be included at the third visit. The importance of adequate follow-up and surveillance requires emphasis.

It seems unlikely that measles will be eradicated. However, it is considered that the present inevitability of measles and its accompanying complications could be alleviated by the availability of free measles vaccine to local authorities, with the consequent saving of lives, suffering, money and manpower.

I should like to express my thanks to members of the Department of Comprehensive and Community Medicine, University of Cape Town, and to Professor A. Kipps, Director of the Virus Research Unit, University of Cape Town, for their help and encouragement with this project.

REFERENCES

Books Received: Boeke Ontvang


