Poliomyelitis surveillance and vaccine efficacy in Bombay, 1982–87

R.J. Kim-Farley,[1] K.H. Dave,[2] J. Sokhey,[3] & V.B. Mandke[4]

Reported are updated data on poliomyelitis surveillance in Bombay for the period 1982–87 and estimates of the efficacy of oral poliovaccine (OPV) calculated by the case exposure method, using two approaches. The first, a screening technique that used only data on the reported number of doses of vaccine administered and the immunization status of all poliomyelitis cases, appeared to underestimate the true vaccine efficacy. In the more rigorous second technique, which used data for children of the same age group, geographical areas, and study year, obtained from immunization coverage surveys, and information on the immunization status of poliomyelitis cases, the results indicate that the OPV vaccine efficacy for fully immunized children aged 12–23 months exceeded 90%.

These findings show that the estimated efficacy of OPV is high in Bombay and that, in general, vaccine efficacy should be re-estimated using more rigorous techniques if preliminary screening estimates indicate a lower than expected efficacy. In Bombay, poliomyelitis therefore results primarily from a failure to fully vaccinate all eligible children rather than as a result of vaccine failure. Furthermore, the age distribution of cases suggests that the strategy of focusing immunization activities on children aged under 1 year is epidemiologically correct.

Introduction

A report has previously appeared on poliomyelitis surveillance and vaccine efficacy in Bombay, determined from data in the Annual Reports of the Enterovirus Research Centre (ERC) of the Indian Council of Medical Research for the period 1949–82 (1). For Greater Bombay, the estimated average efficacy of trivalent oral poliovaccine (OPV) was 86% for the period 1979–81.

In 1985 Bombay was designated as a site for the global "local area monitoring" network of the WHO Expanded Programme on Immunization (EPI), and since then data on population statistics and immunization coverage have been collected from the Public Health Department of the Bombay Municipal Corporation (BMC). Surveillance for poliomyelitis is conducted by the ERC. A description of the local area monitoring programme in Bombay for the period 1974–84 has already appeared (2).

The current OPV immunization schedule for children in Bombay is the same as that used in the rest of India and allows the first dose to be administered to children aged as young as 6 weeks, followed by second and third doses at intervals of at least 4 weeks, respectively, and a supplemental dose at 18 months of age. Prior to 1987 the immunization schedule recommended that OPV be administered to children aged 3, 4, 5, and 18 months.

Here, we present updated poliomyelitis surveillance data for the period 1982–87 that were obtained from the local area monitoring programme and also provide more precise estimates of the effectiveness of OPV in Greater Bombay.

Method

A case of poliomyelitis was defined as a patient who had been diagnosed by a physician to have paralytic poliomyelitis. Patients were considered to be residents of Bombay if their normal address was within Greater Bombay.

To identify cases, an ERC health worker visits at least once each week the four principle hospitals in Bombay that admit children with poliomyelitis: Kasturba Infectious Disease Hospital, B.J. Children's Hospital, J.W. Children's Hospital, and L.T.M.G. Hospital. The ERC also makes efforts to detect cases that are admitted to other public or private hospitals. Periodic visits to the major rehabilitation centre in Bombay helps to detect nonhospitalized cases.

[1] Regional Adviser, Expanded Programme on Immunization, WHO Regional Office for South-East Asia, New Delhi, India, and Medical Officer, Expanded Programme on Immunization, World Health Organization, CH-1211 Geneva 27, Switzerland. Requests for reprints should be sent to Dr Kim-Farley at the latter address.

[2] Director, Enterovirus Research Centre, Indian Council of Medical Research, Bombay, India.

[3] Assistant Commissioner (Immunization), Ministry of Health and Family Welfare, New Delhi, India.

[4] Senior Research Officer, Enterovirus Research Centre, ICMR, Bombay, India.

Information on cases is recorded on standardized forms based on data obtained by the ERC health worker from hospital records and by interviewing the parents of patients. The immunization status of patients is obtained from data on immunization cards or records or from parental histories if no records are available.

Poliomyelitis immunization coverage in Bombay is estimated from reports of the number of OPV doses administered and from the results of standard EPI 30-cluster evaluation surveys.[a] Vaccine efficacy (VE) is calculated using the formula (3, 4):

VE = (Poliomyelitis attack rate (unimmunized) – Poliomyelitis attack rate (fully immunized))/Poliomyelitis attack rate (unimmunized)

This formula can be modified to determine the VE of multiple dose vaccines by including terms for the vaccination status of cases and the population. The resulting formula, which was used to calculate VE in the present study, is given by (5):

$$VE = \frac{(PPV)(PCU) - (PPU)(PCV)}{(PPV)(PCU)} \ .$$

where PCU = proportion of cases unvaccinated against poliomyelitis; PPU = proportion of the population unvaccinated; PCV = proportion of cases vaccinated with the number of doses being examined for vaccine efficacy; and PPV = proportion of the population vaccinated with the number of doses being examined for vaccine efficacy.

The VE was estimated using the case exposure method (4), as follows: by analysing data from all resident cases and assuming that immunization coverage levels for all age groups in a given year are the same as those obtained from the reported number of doses of OPV administered to children aged under 1 year; and by separately analysing data from a subset of cases for the same area, age group, and year for which information was available from an immunization coverage survey. A child receiving three or more doses of OPV was considered as fully immunized. Confidence limits for the vaccine efficacy are not shown, since consensus has not been reached on the most suitable method of calculation (4).

Results

Below are outlined the major findings of the surveillance of poliomyelitis and vaccine efficacy in Bombay for the period 1982–87.

● The impact of the immunization programme cannot yet be measured by a decline in the overall incidence of poliomyelitis in Greater Bombay (Table 1).
● The vast majority of cases of paralytic poliomyelitis occurred among under-2-year-olds (Table 2).
● The majority of children with paralytic poliomyelitis were not immunized, and less than 20% had received three or more doses of OPV (Table 3).
● The immunization coverage levels, estimated from the reported number of doses of OPV administered to children under 1 year of age, indicate that less than half of the children in the Greater Bombay area were fully immunized (Table 4).
● The results of immunization coverage surveys indicate that in some wards of the city the levels of immunization coverage are higher than those estimated for the Bombay area as a whole from the reported number of doses of OPV administered (Table 5).
● The vaccine efficacy, estimated from data on immunization coverage determined from the number of doses of OPV reported to have been administered to children aged under 1 year, and assuming that the coverage was similar for all age groups, ranged from 77% to 84% (Table 6).
● For 1982 and 1983 the vaccine efficacy for fully immunized children aged 12–23 months, estimated from immunization coverage surveys and data on children with poliomyelitis of the same age range and from the same wards of the city (for wards where ⩾10 cases of poliomyelitis occurred), was greater than 90% (Table 7). The vaccine efficacy for partial immunity resulting from administration of one or two doses of OPV was estimated to be 78%, 94%, and 55%, respectively, in wards K, E, and F.

The distribution of poliovirus serotypes that were

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[a] *Training for mid-level managers: coverage survey.* Unpublished document, WHO/EPI/MLM/COV/88.

Table 1: **Number of cases and incidence of paralytic poliomyelitis, Greater Bombay, 1982–87**[a]

| Year | Population (× 10⁶) | No. of cases: | | Morbidity rate (per 100 000) |
		Total	Residents only[b]	
1982	8.578	1458	1116 (77)[c]	13.0
1983	8.862	1283	986 (77)	11.1
1984	9.259	1300	1002 (77)	10.8
1985	9.565	1503	1215 (81)	12.7
1986	9.880	1702	1268 (75)	12.8
1987	10.206	1379	1003 (73)	9.8

[a] Data for 1987 are provisional and do not include data from additional sources. Population data for 1985–87 have been extrapolated from those for previous years.
[b] Residents were defined as individuals whose normal address was in Greater Bombay.
[c] Figures in parentheses are percentages.

Table 2: **Distribution, by age, of numbers of children with paralytic poliomyelitis among residents of Greater Bombay, 1982–87**

Year	Age of onset of poliomyelitis						Total
	0–11 months	12–23 months	24–35 months	36–47 months	≥48 months	Unknown	
1982	500 (45)[a]	433 (39)	127 (11)	29 (3)	26 (2)	1	1116
1983	447 (45)	353 (36)	122 (12)	32 (3)	30 (3)	2	986
1984	379 (38)	444 (44)	115 (11)	36 (4)	28 (3)	0	1002
1985	535 (44)	450 (37)	158 (13)	41 (3)	28 (2)	3	1215
1986	532 (42)	461 (36)	172 (14)	61 (5)	41 (3)	1	1268
1987	422 (42)	405 (40)	122 (12)	34 (3)	20 (2)	0	1003

[a] Figures in parentheses are percentages.

Table 3: **Distribution, by immunization status, of numbers of children with paralytic poliomyelitis among residents of Greater Bombay, 1982–87**

Year	Unimmunized	Partially immunized	Fully immunized	Unknown	Total
1982	734 (66)[a]	151 (14)	164 (15)	67 (6)	1116
1983	674 (68)	158 (16)	151 (15)	3	986
1984	619 (62)	197 (20)	134 (13)	52 (5)	1002
1985	785 (65)	227 (19)	196 (16)	7 (1)	1215
1986	736 (58)	246 (19)	227 (18)	59 (5)	1268
1987	599 (60)	234 (23)	167 (17)	3	1003

[a] Figures in parentheses are percentages.

Table 4: **Estimated polio immunization coverage of children in Greater Bombay, based on the number of doses of oral poliovaccine (OPV) administered to children aged under 12 months, 1982–86**

Year	No. of doses:				Population of under-1-year-olds[a]
	No OPV	OPV1	OPV2	OPV3	
1982	75 408 (40)[b]	112 291 (60)	85 346 (45)	74 152 (40)	187 699
1983	60 181 (31)	132 204 (69)	102 622 (53)	83 792 (44)	192 385
1984	69 921 (36)	126 601 (64)	90 275 (46)	72 277 (37)	196 522
1985	75 535 (38)	125 310 (62)	108 401 (54)	83 944 (42)	200 845
1986	55 579 (27)	149 685 (73)	121 851 (59)	92 646 (45)	205 264

[a] The population of under-1-year-olds in Greater Bombay for 1985 and 1986 was obtained by extrapolating from data for previous years.
[b] Figures in parentheses are percentages.

Table 5: **Estimated percentage immunization coverage, by dose, with oral poliovaccine (OPV), as determined in coverage surveys, for children aged 12–23 months in selected wards of Greater Bombay, 1982–83**

Year and ward	No. of doses:			
	No OPV	OPV1	OPV2	OPV3
1982: K	24	76	70	63
1983: F/S	15	85	78	72
B	18	82	75	65
E	14	86	83	75

circulating in wards K, E, and F was similar to that in the other wards of Bombay. In 1982, these were primarily poliovirus 1 and 3, while in 1983, all three viral serotypes were represented. Wards K, E, and F consist of a combination of slum and nonslum areas and are representative of Bombay as a whole.

Discussion

In the study, the estimates of the efficacy of OPV increased as the techniques used in the case exposure method became more rigorous.

The first estimate was determined by a screening

Table 6: **Estimated efficacy of oral poliovaccine (OPV) based on immunization coverage of children (Greater Bombay residents), by the number of doses administered, 1982–86**

Year	% immunization coverage (by doses adminstered)		Immunization status of cases (%):		
	Zero	OPV3	Zero	Fully	Vaccine efficacy (%)
1982	40	40	66	15	77
1983	31	44	68	15	84
1984	36	37	62	13	79
1985	38	42	65	16	78
1986	27	45	58	18	81

Table 7: **Estimated efficacy of oral poliovaccine (OPV) based on data from coverage surveys of children aged 12–23 months and the immunization status of cases (the same age and wards), Greater Bombay, 1982–83**[a]

Year and ward	Immunization coverage (%)			Immunization status of cases (%):		
	Zero	OPV3	No. of cases[b]	Zero	Fully	Vaccine efficacy (%)
1982: K	24	63	122	77	14	93
1983: E	14	75	31	71	26	93
F	15	72	91	59	18	94

[a] For wards with ≥ 10 cases of poliomyelitis.
[b] Excluded were children of unknown immunization status: 4, 3, and 3 cases in wards K, E, and F, respectively.

approach, which used data on all poliomyelitis cases among residents and assumed that immunization coverage levels for all children were the same as those determined from the number of reported doses of vaccine administered to children aged under 12 months (see Table 6). The vaccine efficacies thus obtained are probably inaccurate because immunization coverage levels for children aged under 12 months do not accurately represent those for other age groups and no account was taken of OPV administered in private health facilities.

The results of the second approach to estimating vaccine efficacy, which used data on cases of poliomyelitis and from immunization coverage surveys for the same areas, age group, and year, were more accurate (see Table 7). This method is, however, more difficult to carry out, since it requires data from

immunization coverage surveys and separate analysis of data on poliomyelitis cases by age.

The estimated vaccine efficacy in the K ward of Bombay primarily represented that for poliovirus 1 and 3, while that in the E and F wards was a combined efficacy against all three serotypes. The sample sizes were, however, too small to permit calculation of the vaccine efficacy by serotype.

That the overall incidence of poliomyelitis has not yet decreased in Bombay could be due to a number of factors; for example, the nonhomogeneity of OPV coverage could have resulted in pockets of unimmunized populations (evidence for which is provided by spot maps of cases), and the large-scale in-migration of persons (many of whom may not have been immunized in their previous place of residence) might not have been fully taken into account in the population estimates used to determine the incidence of the disease.

Conclusions

Based on the more rigorous analysis of data on cases of poliomyelitis and immunization coverage shown in Table 7, the estimated vaccine efficacy of OPV for fully immunized children aged 12–23 months exceeded 90% in Greater Bombay.

The approaches that we have described could be useful for immunization programme managers in estimating vaccine efficacy in their areas of responsibility (5). Other methods of estimating vaccine efficacy, including case–control studies, as well as the statistical basis for such estimates, have been reviewed by Orenstein et al. (3, 4).

The encouragingly high estimated vaccine efficacy indicates that in Bombay poliomyelitis is caused primarily by incomplete vaccination coverage of all eligible children rather than by vaccine failure. The age distribution of cases indicates that the strategy of focusing immunization activities on children under 1 year of age is epidemiologically correct. However, it is important that coverage levels for OPV continue to increase in Bombay to bring about a decrease in the incidence of poliomyelitis in the city.

Addendum

One of the authors (J.S.) reported on 1 November 1989 a substantial decline in the number of cases of paralytic poliomyelitis, as recorded in the last two years. A total of 643 cases were reported in 1988, including 382 resident children. As of the end of September 1989, a total of 360 cases have been reported in 1989.

Résumé

Surveillance de la poliomyélite et efficacité de la vaccination à Bombay, 1982–1987

Cet article présente les dernières données sur la surveillance de la poliomyélite à Bombay de 1982 à 1987, ainsi que les estimations de l'efficacité du vaccin antipoliomyélitique buccal (VPO), calculées selon deux variantes de la méthode "cas/sujets exposés". La première de ces variantes, une technique de calcul sommaire ne prenant en compte que le nombre de doses de vaccin administrées et l'état vaccinal de tous les cas de poliomyélite, sous-estime l'efficacité réelle du vaccin. La seconde technique, plus rigoureuse, est fondée à la fois sur des informations concernant l'état vaccinal des cas de poliomyélite et sur des données recueillies lors des enquêtes sur la couverture vaccinale des enfants du même groupe d'âge, dans les mêmes secteurs géographiques et au cours de la même année d'étude. On constate alors que l'efficacité du VPO, chez les enfants de douze à vingt-trois mois complètement vaccinés, dépasse 90%.

Ces résultats montrent que le VPO est très efficace à Bombay et qu'en général, si les estimations préliminaires indiquent une efficacité moins grande que prévu, il convient de réévaluer celle-ci à l'aide de techniques plus rigoureuses. A Bombay, les cas de poliomyélite sont donc moins le résultat d'un échec de la vaccination que d'une couverture vaccinale incomplète. De plus, la distribution des cas en fonction de l'âge semble indiquer que la stratégie consistant à vacciner en priorité les enfants âgés de moins d'un an est justifiée du point de vue épidémiologique.

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