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ORIGINAL ARTICLES

The changing age ecology of measles and its implications on measles control

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SUMMARY

In the City of Gweru measles vaccination was commenced in 1971. With the advent of the Expanded Programme on Immunisation in 1981–82, measles vaccination coverage was increased, reaching over 80 pc in 1985 and after. Despite this vaccination effort measles morbidity rates have remained high and epidemics continue to occur periodically. It is argued that the shift of the disease from young age groups to older children, coupled with the fact that there are more vaccinees amongst cases with the disease, will mean that transmission will continue uninterrupted. Possible reasons for persistent transmission in older children are explored. It is concluded that measles revaccination is required to interrupt measles transmission.

INTRODUCTION

World-wide an estimated two million children die from measles and its complications every year.[1] Severe measles is limited geographically to developing countries where it is unquestionably one of the most prevalent and serious infectious diseases of childhood.[2] This gruesome epidemiological picture has provided a strong priori case for measles prevention through immunisation.

In the City of Gweru in Zimbabwe, vaccination against measles was commenced in 1971, gained momentum in the late seventies and was accelerated and consolidated with the advent of the Expanded Programme on Immunisation (EPI) in 1982-83. In this paper we shall examine how, despite aggressive efforts aimed at controlling measles through vaccination, it would not be possible to interrupt measles transmission with the single nine months of age vaccination regime, due to the changing age epidemiology of the disease.

MATERIALS AND METHODS

This study was carried out in the City of Gweru, the third largest city in Zimbabwe with a total population of 110 000 people.

In Gweru measles vaccination is done as part of the EPI effort. A single dose of live hyperattenuated Schwarz strain vaccine (0.5mls or 1000 TCID50) is administered to infants at nine months of age. Surveillance of immunisation activities (including measles morbidity and mortality data) is managed through records and disease registers of the routine health information system. The data indicated hereunder are extracted from this source.

RESULTS

Measles vaccination in the under fives rose from 1.8 pc in 1971 to 90.7 pc in 1989, a fifth fold increase in an 18 year period. Commencement of the EPI in 1981-82 brought forth a rise in the vaccination coverage from 66 pc in 1982 to 91 pc in 1989. (See Table 1 and Figure 1).

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Figure I: Measles immunisation coverage in age group 0–5 years (1971–89)

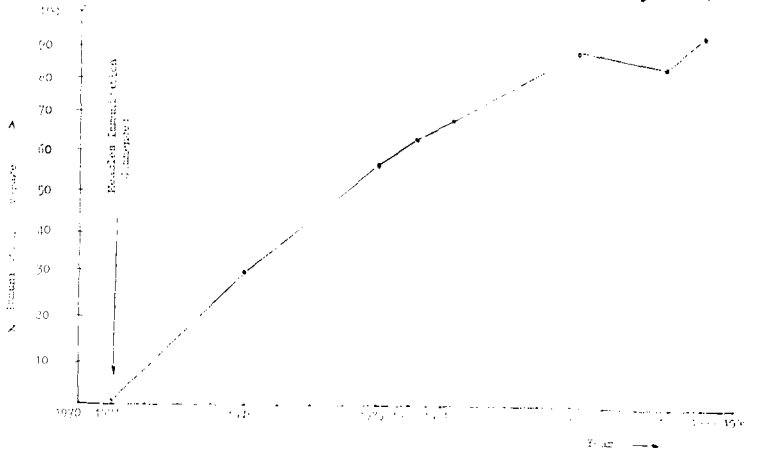


Table I: Measles immunisation coverage in the age group 0–5 years

Year	1971	1975	1979	1980	1981	1985	1988	1989
Population 0– years	11459	11057	12476	13943	15867	26302	23884	18933
Population vaccinated	203	3177	7186	8350	10259	22561	20135	17168
pc Coverage	1.78	28.73	56.38	63.47	64.66	85.73	84.30	90.68

Measles mortality rate has declined from an all high of 115/1000 000 population in 1968 to zero in 1989. A steady decline in measles mortality commenced from 1970. By 1980 the mortality rate had dwindled to 6/100 000 population. (See Table II and Figure II).

Measles epidemics continue to occur periodically and their magnitude resembles that of the pre-immunisation era. Annual incidence rates of measles remain high. (See Table III and Figure III)

Table IV represents the age distribution of cases of measles between 1968 and 1989. From 1968 to 1989 the age group 0–9 months' contribution to the annual incidence of measles has varied between 4 pc and 12 pc. In the 21 year period to 1989 the age group's annual contribution to measles incidence has averaged 8 pc (See Table V)

Between 1968 and 1983 the age group 0–23 months dominated the morbidity picture. In this period the age group accounted for over 50 pc measles cases annually. The four year period 1983 to 1986 represents a transitional phase in which the proportion of cases occurring amongst older children of 60 months of age and over begins to increase and this feature is well established after 1988, with this

Table II: Measles Mortality — annual mortality, mortality rates and fatality rates (Disease specific mortality, mortality rates and fatality rates

Year	1961	1964	1967	1968	1970	1971	1974	1975	1977
Total Population	27283	40851	44588	45376	46172	48631	57569	59777	64840
Annual measles deaths	5	24	49	52	26	17	14	3	5
Annual measles mortality rate per 100 000 population	13	59	110	115	56	35	24	5	8
Measles fatality rate per 100 cases	8	22	48	38	25	15	6	6	2

Year	1979	1980	1981	1982	1983	1986	1987	1988	1989
Total Population	66381	69786	74181	76955	81648	99055	102350	105532	108671
Annual measles deaths	10	4	2	3	11	0	0	1	0
Annual measles mortality rate per 100 000 population	15	6	3	4	13	0	0	1	0
Measles fatality rate per 100 cases	5	3	2	1	3	0	0	6	0

Figure II: Measles disease-specific mortality rate per 100 000 population

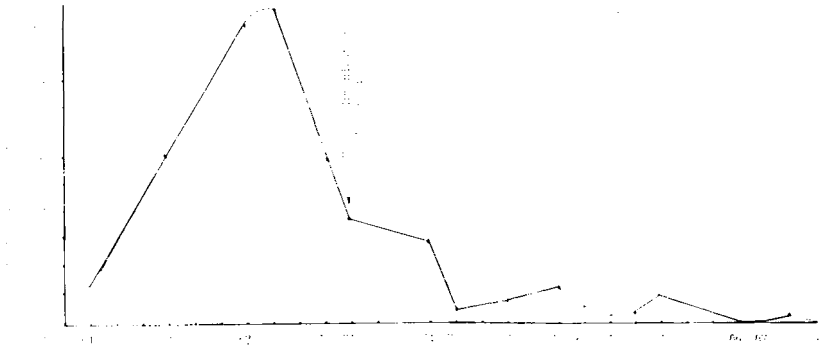
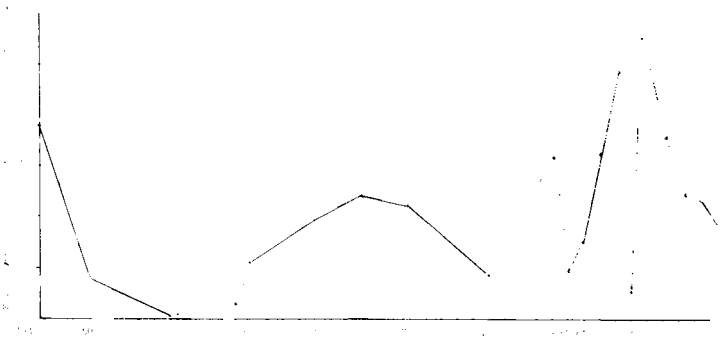


Table III: Measles-annual incidence and incidence rate (Disease specific morbidity in the total population)

Year	1947	1950	1955	1959	1960	1964	1967	1970	1975	1979
Total population	28055	30035	33079	35729	36577	40851	41588	48631	59777	66381
Annual incidence	107	26	2	10	41	109	83	103	52	210
Incidence rate per 100 000 population	381	87	6	28	112	198	231	212	87	316

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total population	69786	76955	76955	81648	89715	95310	99055	102350	105532	108671
Annual incidence	91	115	244	418	50	527	356	267	271	164
Incidence rate per 100 000 population	130	155	317	512	56	553	359	261	257	151

Figure III: Measles annual incidence rates 1947-1989



age group accounting for 59 pc of measles cases annually.

Data on vaccination status of cases is available from 1980 (See Table VII) By 1982 the age group 10–59 months had more vaccinated than unvaccinated cases, 59 pc and 41 pc respectively. This phenomenon occurred two years later in 1984 for the age group 60–119 months when the vaccinated cases accounted for 60 pc of cases while the unvaccinated accounted for 40 pc cases.

Both age groups have since then registered more vaccinated cases than unvaccinated. The age group 120 months plus, although it has contributed no more than 13 pc to measles annual incidence in any one year, has in the past 10-year period contributed more unvaccinated cases than vaccinated (See Table VIII).

Table IV: Measles annual incidence by age group

Year	Age Groups (in months) 0–9	0–1	12–23	24–35	36–47	48–59	60–71	72–83	84–95	96–107	105–119	120+	Annual Incidence
1968	8	26	56	16	18	11	2	4	0	2	0	3	138
1970	7	15	39	10	11	4	2	2	6	3	3	8	103
1971	5	17	36	13	10	7	4	4	4	4	4	11	114
1975	2	11	23	5	3	3	3	2	0	0	0	2	52
1979	10	28	67	24	16	15	8	13	14	5	3	17	210
1980	12	15	46	23	11	3	6	6	1	2	3	10	126
1981	10	22	48	7	7	4	3	5	6	2	4	7	115
1982	22	36	95	32	27	11	9	9	5	6	3	11	244
1984	5	9	11	13	5	4	4	7	0	0	0	2	49
1985	54	72	87	78	65	62	37	30	18	25	11	52	527
1987	20	28	45	19	26	21	25	40	25	10	7	21	267
1988	19	31	27	25	18	23	26	48	22	23	11	17	271

Table V Measles incidence in the age group 0–9 months (1968–1989)

Year	Cases	pc of total annual incidence
1968	8	6
1970	7	7
1971	5	4
1975	2	4
1979	10	5
1980	12	10
1981	10	9
1982	22	9
1984	5	10
1985	54	10
1987	20	8
1988	19	7
1989	19	12

DISCUSSION

In Gweru the measles mortality rate has declined dramatically. Going by experience elsewhere it can not be doubted that immunisation has played a role in this decline.[3]

What has vexed us is that despite a high measles vaccination coverage and a rosy mortality picture, measles morbidity rates are unyielding. This we have understood to mean that the degree of exposure and susceptibility of the child population to the disease has remained the same over the years.

In some developing countries the age group zero–nine years has been responsible for high rates of measles transmission to a point where WHO has recommended that the "high titre" Edmonston-Zagreb (EZ) measles vaccine be

Table VI: Measles incidence in the age groups 0–23 months and 60 months+ (1968–1989)

Year	Measles Annual Incidence	0–23 months Cases	0–23 months pc of annual Incidence	60 months+ Cases	60 months+ pc of annual Incidence
1968	138	82	59	11	8
1970	103	54	52	24	23
1971	114	53	47	31	27
1975	52	34	65	7	14
1979	210	95	45	60	29
1980	126	61	48	28	22
1981	115	70	61	27	24
1982	244	131	54	43	18
1984	49	20	41	7	14
1985	527	159	30	173	33
1987	267	73	27	128	48
1988	271	58	21	147	54
1989	164	37	23	89	54

Table VII:Measles annual incidence by age groups vs vaccination status

Year	Measles annual incidence by age groups in months and vaccination status																						Measles Annual Incidence
	0–9m		10–11m		12–23m		24–35m		36-47m		48–59m		60–71m		72–83m		84–95m		96–107m		108–119m		120+m		
	+	—	+	—	+	–	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	
1980		12	2	1	12	34	1	22	2	9	1	2	4	2	4	2	0	1	0	2	0	3	2	8	126
1981		10	1	11	23	25	2	5	2	5	0	4	0	3	4	1	1	5	1	1	0	4	0	7	115
1982		22	11	3	52	43	18	14	17	10	8	3	4	5	4	5	2	3	3	3	2	1	4	7	244
1983		53	23	2	78	62	29	24	23	15	13	6	7	4	3	8	6	2	6	9	3	5	5	32	418
1984		5	3	1	5	6	10	3	3	2	2	2	2	2	1	0	0	0	0	0	0	0	0	2	49
1985		54	14	4	54	33	51	27	30	35	30	22	22	15	16	14	7	11	11	14	5	6	8	44	527
1986		31	13	7	37	17	30	13	29	9	27	9	26	14	23	5	11	8	4	7	3	3	5	25	356
1987		20	5	3	34	11	15	4	21	5	18	3	19	6	35	5	24	1	6	4	4	3	7	14	267
1988		19	8	4	17	10	14	11	13	5	18	5	23	3	30	18	15	7	16	7	4	7	3	14	271
1989		19	4	3	10	1	13	4	11	3	5	2	7	1	13	10	11	9	8	4	3	2	1	20	164

+=Vaccinated
—Not vaccinated

Table VIII: Vaccination status of cases for the age groups 10–59 months, 60–119 months and 120 months+ (1980–1989)

Year	10–59 months			60–119 months			120 months+		
	No. of Cases	Vaccinated No. pc	Unvaccinated No. pc	No. of Cases	Vaccinated No. pc	Unvaccinated No. pc	No. of Cases	Vaccinated No. pc	Unvaccinated No. pc
1980	86	18 (21)	68 (79)	18	8 (44)	10 (56)	10	2 (20)	8 (80)
1981	74	28 (38)	46 (62)	20	6 (30)	14 (70)	7	0 (0)	7 (100)
1982	179	106 (59)	73 (41)	32	13 (41)	19 (59)	11	4 (36)	7 (64)
1983	275	166 (60)	109 (40)	55	27 (49)	28 (51)	37	5 (14)	32 (86)
1984	37	23 (62)	14 (38)	5	3 (60)	2 (40)	2	0 (0)	2 (100)
1985	300	179 (60)	121 (40)	121	61 (50)	60 (50)	52	8 (15)	44 (85)
1986	191	136 (71)	55 (29)	104	67 (64)	37 (36)	30	5 (17)	25 (83)
1987	119	93 (78)	26 (22)	107	88 (82)	19 (18)	21	7 (33)	14 (67)
1988	105	70 (67)	35 (33)	130	88 (68)	42 (32)	17	3 (18)	14 (82)
1989	56	43 (77)	13 (23)	68	42 (62)	2 (38)	21	1 (5)	20 (95)

administered to infants at six months of age [2,4,5]. Occurrence of measles before the age of nine months in infants is not a problem of public health importance in our experience Measles studies carried out in rural Zimbabwe show a similar picture.[6] On account of this we have had no epidemiological imperative to vaccine children before the age of nine months.

We have witnessed an altered age character of the disease. An increasing and greater proportion of cases now occurs in the older age groups of 60 months of age plus, as opposed to the traditionally exposed and susceptible population of 23 months of age and under, who bore the brunt of measles transmission prior to widespread measles immunisation. Immunisation (particularly high immunisation coverage, but of less than 100 pc uptake, whose target age group has been children under two years) is said to be responsible for this change in the epidemiological pattern of measles.[2] A similar picture has been observed in rural Zimbabwe. [6] The shift to older children in the transmission pattern of the disease is exacerbated by the fact that this is occurring to a school-going population and schools are known to be fertile grounds for transmission of measles.[7]

The proportion of cases which occurs amongst previously vaccinated children has been increasing. This is an expected consequence of a high coverage.[2,8] However, in a situation like ours where morbidity rates have remained high in the face of a vaccination effort amounting to a coverage of over 80 pc in the six years up to 1989, measles cases occurring amongst vaccinees are suspect. This is particularly so when cognisance is taken of the fact that they have continuously accounted for over 60 pc of cases in the four years to 1989 in both the 10–59 months and 60–119 months age groups. This picture

has given us reason to believe that vaccines are supporting transmission and are consequently fuelling the pool of susceptibles.

Einnemann reports that in some studies measles occurring in previously vaccinated children have contributed significantly to perpetuation of epidemics. In community outbreaks from four to 32 pc of cases have involved vaccinated children and in school epidemics 89 pc. When vaccine efficacy has been determined in these epidemics it has ranged from 67 pc to 90 pc the overall vaccine efficacy has been about 90 pc.[9] May be this set of circumstances explains the mechanism by which the shift of the disease to older school-going children contributes to maintenance and perpetuation of high measles morbidity rates.

Another epidemiological peculiarity we have observed relates to an increasing occurrence of predominantly unvaccinated cases aged 120 months and over. This phenomenon has also been observed in measles studies carried out in the rural Zimbabwe.[10] It could be that these people were spared from contracting measles in early childhood due to protection from herd immunity.

What are the implications of these findings?

1. As indicated earlier we do not see the need to vaccinate any child earlier than nine months of age.

2. Although there has been a shift in the transmission of the disease from young to older children, the young children (under 23 months of age) represented 23 pc of all cases of the disease in 1989. Thus their level of contribution to transmission of the disease, we believe, is substantiated and consequently we will maintain the policy of vaccinating children at nine months of age.

3. The shift of the disease to older children many of whom are vaccinated has meant to us that they are not adequately protected by the single nine month dose. Within our experience, the other childhood immunisable conditions such as pertussis, polio, diphtheria and tetanus, for which several vaccinations are required for each child to effect meaningful immunity, have virtually disappeared at a vaccination coverage of over 80 pc. Given this background we have had reason to believe that possibly due to either age at vaccination (in relation to maternal antibody activity at nine months of age) or hyperattenuation of the vaccine (or both) when we vaccinate them young, the immunogenicity of the vaccine is compromised. As the children advance in age their immunocapacity declines and consequently renders them susceptible to infection. It is thus possible that if they were to be revaccinated, possibly at school entry, their immunocapacity would improve and this might interrupt measles transmission in the older children. Ebrahim has observed that vaccine-induced immunity should be considered as long term rather than life long and consequently if there is a reappearance of the disease in immunised populations revaccination should be considered.[11]

CONCLUSION

There is distinct possibility that as the level of immunity improves among children, disease transmission could shift to young adults and older people. In fact a trend towards adult measles has been observed in the United Kingdom.[12] The public health implications of such a shift remain unclear but it could turn out to be disastrous particularly in relation to severity of the disease and the effects of the disease on pregnant women. What all this means is that the present immunisation practice in developing countries cannot interrupt measles transmission. To wholly interrupt the disease may require a vaccination regime with boosters (revaccination) to ensure that as the young population proceeds into adulthood they are adequately protected from the disease.

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