Measles control in developing and developed countries: the case for a two-dose policy

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Despite major reductions in the incidence of measles and its complications, measles control with a single dose of the currently used Schwarz strain vaccine has failed to eradicate the disease in the developed countries. In developing countries an enormous toll of measles deaths and disability continues, despite considerable efforts and increasing immunization coverage. Empirical evidence from a number of countries suggests that a two-dose measles vaccination programme, by improving individual protection and herd immunity can make a major contribution to measles control and elimination of local circulation of the disease. Cost-benefit analysis also supports the two-dose schedule in terms of savings in health costs, and total costs to society. A two-dose measles vaccination programme is therefore an essential component of preventive health care in developing, as well as developed countries for the 1990s.

Introduction

Measles continues to be a serious public health problem in developing as well as developed countries, despite the availability of an excellent vaccine. The disease causes an estimated 1.4 million deaths annually, primarily in developing countries, but also occurs in outbreaks in developed countries, even where there is a well-established immunization programme (1-6). Full control of the disease has not been achieved, in part because of the difficulty in reaching the needed coverage of infant populations to achieve the necessary levels of herd immunity even in developed countries, and because of problems of both primary and secondary vaccine failure (7-31). As a result, views have been proposed that measles cannot be eradicated, without application of the lessons learned in the developed countries to developing countries (4-7).

Current estimates of the coverage needed for fully protective herd immunity are 94-97% (4). This level is very difficult to reach with 15-month-old infants even in the most developed countries, but it may be more readily achievable with school-age children through compulsory vaccination. In addition, there is the problem of vaccine failure, particularly when the vaccine is administered before the optimal time. Primary vaccination failure occurs at rates of 4-8%, and secondary failure at about 4% (4, 22). Also, large numbers of cases occur among apparently appropriately vaccinated persons during epidemics, particularly in group settings such as schools, universities or sporting events. Many countries have experienced an upward shift in the age group of measles cases to those who may have been immunized before 1980 either too early, or with less stable vaccine preparations. Therefore, even 95% vaccination coverage of children up to 2 years of age is insufficient to fully control or eliminate this disease. In order to deal with these limitations, some countries have adopted a two-dose policy: one dose in infancy and a booster, usually at school age. All the available evidence suggests that two doses are justified and indicated in both developed and developing countries to achieve control of this disease.

Recent measles experience in a number of developed and developing countries is reviewed here, including recent literature on vaccine efficacy, as well as cost-benefit studies. The weight of evidence favours universal adoption of the two-dose schedule to achieve maximum feasible control of this vaccine-preventable disease.

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**Materials and methods**

Measles incidence data were examined as reported to the WHO European Regional Office, the Centers for Disease Control in Atlanta (USA), the Laboratory for Disease Control in Ottawa (Canada), the Government Health Services in Judea/Samaria (West Bank) and Gaza, and the Department of Epidemiology of the Ministry of Health of Israel. We also examined published data for the Ministries of Health of the Philippines, Nigeria, and Malawi, and data assembled by UNICEF on population, mortality and immunization coverage.

**Findings**

**Developed countries**

**United States of America.** In 1988 the population was 245.4 million, with a GNP per capita of US$ 19,840 and an infant mortality rate of 11/1000. Measles vaccination coverage of one-year-olds was reported as 96% in 1981, 82% in 1987/88, and 98% in 1988/89 (5); all states have mandatory immunization requirements for school entry, school attendance being virtually universal.

Measles was present in all parts of the USA prior to the introduction and widespread use of the vaccine. Between 1950 and 1959 the annual average of reported cases was 500,000, estimated to be 10% of the actual total, with 500 deaths per year (4). Dramatic reductions (97–98%) occurred in measles incidence, from rates of 400–600 per 100,000 in the pre-vaccination period (prior to 1963) to under 5 per 100,000 in the 1981–85 period, but epidemics are continuing among both immunized and unimmunized populations well into the 1990s (6–9).

In 1985–86, 67% of the 88 documented measles outbreaks occurred among school-age persons (5–19 years), with a median immunization history of 60% (6–18). In 1987, 57% of the 3,655 reported cases of measles were in this age group, and 72% had been appropriately immunized (24). In 1989, 57% of a total of 3,411 cases occurred among school-age children, 69% of whom had been vaccinated appropriately. School-based outbreaks were identified as the trigger event, with wider spread of the disease and greater severity among secondary cases (25).

As a result of these disturbing developments, the earlier optimism that measles could be eradicated gave way to a search for a new approach. In 1989, the Immunization Practice Advisory Committee for the United States recommended a two-dose measles vaccination policy (26–29). During 1990 and 1991, major epidemics occurred in the USA, and in contrast to the 1987–89 epidemics, these were primarily among unimmunized infants in crowded urban slum areas (30–34).

**Canada.** In 1988 the population was 26 million, with a GNP per capita of US$ 16,960 and an infant mortality rate of 7 per 1000. Measles immunization coverage of one-year-olds was reported as 85% in 1988/89 (5) using a single dose of measles vaccine, with mandatory school entry vaccination. Measles incidence rates declined from the 300–400 per 100,000 in the late pre-vaccination era, to 9.4 per 100,000 in 1987 and 2.4 per 100,000 in 1988 (35).

Despite the overall decline in measles incidence after the introduction of routine vaccination, widespread epidemics occurred in 1986 and 1989 which included highly immunized populations (35–39). In 1989 a measles epidemic with over 10,000 cases occurred in Quebec, primarily among a highly immunized population of school-age children and teenagers (40–42). In Quebec City, even though 98% of primary school children and 97% of high school students had records of measles immunization, a large outbreak occurred.

In 1990–91, an outbreak occurred in Waterloo, Ontario, with 1,184 cases, over 70% of them among 5–19-year-olds (43). Two-thirds of these cases had received appropriate immunization. There were 61 hospitalized cases (median age, 5.8 years), which were more frequent among the unimmunized. According to the Canada Diseases Weekly Report (16), “fairly extensive outbreaks of measles have been occurring in Canada since 1989 despite universal immunization of children for over 20 years”. However, the Canadian Advisory Committee on Immunization Practice recommended continuation of the one-dose policy, along with mandatory school-age proof of immunization or prior measles, and outbreak control strategies (44, 45).

**Europe.** A number of European nations adopted a two-dose policy during the 1980s, while others continue with a single-dose. Table 1 shows measles incidence in these countries as reported in the 1990 WHO European Region’s Health-for-All data set. This includes countries which had a two-dose policy for measles vaccination from 1984 or before, those which adopted this policy after 1984, and the majority which still had a one-dose policy up to 1990.

Some countries have seen dramatic reductions in annual average incidence rates, while others have remained high. Countries with a two-dose policy experienced reductions in measles incidence rates of 73–99% from the period 1974–77 to 1983–87. The three countries which adopted the two-dose policy after 1984 saw reductions in measles incidence of 41–81%. Of the 11 countries reporting with a one-dose policy, four had measles incidence reductions...
Table 1: Average annual incidence of measles in reporting European countries, 1974/77 to 1983/87

<table>
<thead>
<tr>
<th>Country</th>
<th>Average annual incidencea</th>
<th>% of vaccinated one-year-oldsb</th>
<th>% decline from 1974/77 to 1983/87</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Two-dose policy since 1984 or before:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>224</td>
<td>174</td>
<td>53</td>
</tr>
<tr>
<td>Sweden</td>
<td>129</td>
<td>65</td>
<td>35</td>
</tr>
<tr>
<td>Finland</td>
<td>140</td>
<td>67</td>
<td>31</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>227</td>
<td>47</td>
<td>10</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>113</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td>Hungary</td>
<td>114</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td><strong>Two-dose policy after 1984:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>638</td>
<td>643</td>
<td>377</td>
</tr>
<tr>
<td>Israelb</td>
<td>50</td>
<td>47</td>
<td>15</td>
</tr>
<tr>
<td>Netherlands</td>
<td>16</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>One-dose policy:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>64</td>
<td>43</td>
<td>206</td>
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<tr>
<td>Spain</td>
<td>415</td>
<td>360</td>
<td>210</td>
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<tr>
<td>United Kingdom</td>
<td>240</td>
<td>194</td>
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</tr>
<tr>
<td>Italy</td>
<td>78</td>
<td>71</td>
<td>74</td>
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<tr>
<td>Greece</td>
<td>104</td>
<td>59</td>
<td>59</td>
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<tr>
<td>Poland</td>
<td>283</td>
<td>107</td>
<td>59</td>
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<tr>
<td>Romania</td>
<td>552</td>
<td>264</td>
<td>51</td>
</tr>
<tr>
<td>Iceland</td>
<td>347</td>
<td>29</td>
<td>49</td>
</tr>
<tr>
<td>Turkey</td>
<td>49</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>German Dem. Rep.</td>
<td>10</td>
<td>47</td>
<td>27</td>
</tr>
</tbody>
</table>

a Average annual rates per 100 000 population. Includes countries reported in Health-For-All data set. Copenhagen, WHO Regional Office for Europe, 1990.


c Not including the West Bank and Gaza.

of over 70%, while the remainder had substantially smaller reductions, or even increased incidence rates during this period.

Some of these differences are due to the fact that those countries with a one-dose policy have lower average vaccination coverage of one-year-olds than those with a one-dose programme (74% versus 92% in 1987/88). Some of these differences are almost surely due to the effect of the second measles vaccination, and some may be the result of reporting differences, but this cannot be quantified from the available data.

**Netherlands.** The Netherlands has a population of 14.6 million, a GNP per capita of US$ 14 520, and an infant mortality rate of 8/1000. Measles vaccination coverage rates of one-year-olds were reported as 93% in 1981 and 1988/89 (5). The Netherlands has had very low measles incidence rates since the late 1970s. The national immunization programme has, since 1987, used MMR (measles-mumps-rubella vaccine) at 14 months and at 9 years, with MMR also given at 4 years as a catch-up programme, with 89–90% coverage for the second dose (46).

**Finland/Sweden.** Finland, with a population of 5 million, in 1988 had a GNP per capita of US$ 18 590 and an infant mortality rate of 6/1000. Measles immunization coverage of one-year-olds, reported at 70% in 1981, increased to 87% in 1987/88 and to 95% in 1988/89 (5). MMR is given at 18 months, and a second dose at 6 years (55). Finland’s average annual incidence of measles fell from 140 per 100 000 in 1974–77 to 31 per 100 000 in 1983–87.

Sweden had a population of 8.3 million, a GNP per capita of US$ 19 300, and an infant mortality rate of 6/1000 in 1989. Measles immunization coverage was reported as 56% in 1981, 93% in 1987/88, and 94% in 1988/89 (5). The two-dose measles vaccination programme, given at 18 months and 12 years, commenced in 1982 with 88% coverage of the second dose. Measles incidence fell from 129 per 100 000 in the 1974/77 period to 35 per 100 000 in
1983–87 (5), and from 76 per 100 000 in 1982 to under 1 per 100 000 since 1988.\textsuperscript{a}

\textbf{United Kingdom.} The United Kingdom had a population of 56.8 million, a GNP per capita of US$ 12 810, and an infant mortality rate of 8/1000 in 1988 (5). Measles vaccine was used alone (given at age 12–24 months) until MMR was adopted in 1989. Measles vaccination of one-year-olds was reported as 52% in 1981, 76% in 1987/88, and 80% in 1988/89 (5), with concern being expressed over unsatisfactory coverage (47). Measles immunization coverage rates vary by region from 60% to 85%, with continuing high rates of measles incidence (167 per 100 000) in the period 1983–87 and as many as 20 deaths per year (48). Epidemics continued to occur every 2–3 years during the 1980s, reaching 86 000 notified cases in 1988, with 6 measles-associated deaths, falling to some 26 000 cases reported in 1989 (49). A second dose of measles vaccine was decided upon in late 1990 (S. Rosenthal, personal communication, 1991).

\textbf{Mixed developing areas}

\textit{Israel, West Bank and Gaza.} Israel had a population of 4.7 million in 1990, an infant mortality rate of 11/1000 (1985–88), and a GNP per capita of US$ 8650 (1988). Measles immunization was adopted in 1967 in Israel, with coverage reported as 82% in 1975 and 1980, increasing to 85% in 1985 and 88% in 1989 (52, 56).

Measles cases and incidence rates in Israel are shown in Table 2 for the years 1968–91. The total of reported measles cases rose from 7455 in the period 1968–72 and 6786 in 1973–77 to 9344 in 1978–82, and then fell to 5777 in 1983–87 and 1469 in 1988–91. Large-scale epidemics occurred in 1975, 1979, 1982 and 1985/86, and again in 1991 (51–56).

Subacute sclerosing panencephalitis (SSPE), a universally fatal neurological disorder occurring some 6–8 years after measles exposure, was documented in Israel in 108 cases during the period 1960 to 1979, but a sharp decline was seen some 10 years after the introduction of measles vaccination (51). Mortality from measles fell from 108 deaths in the decade 1968–77, to 49 in 1978–86 and 8 in 1987–91. Case fatality rates (deaths per 1000 reported cases) were 6/1000 in 1973, 10/1000 in 1983–84 and declined to 3/1000 1985–86 (52).

Continuation of unacceptably high measles incidence, and especially measles epidemics occurring in 3–4 year cycles throughout the 1980s, with anticipation of a new epidemic in 1990–91, along with the difficulty of reaching the 95%+ coverage that is required for full herd immunity, led to the adoption of the two-dose policy in Israel in 1989. MMR was adopted in place of measles vaccine alone at 15 months, and measles vaccination was added at school entry age, along with a gradual catch-up of other school-age children by 2–3 school grades nationally per year since 1990 (53, 54, 56).

The West Bank had a population of 955 000 in 1990, a 1989 GNP per capita of US$ 1973 (increased from $836 in 1975), and an infant mortality rate of some 30/1000 in 1988. Measles vaccination was introduced in the West Bank in 1973, reaching over 80% coverage of children at age 1 year in the mid-1980s, and close to 90% by the end of the 1980s.

Measles incidence in the West Bank declined, as seen in Table 2; deaths from measles also declined, from 75 in the period 1974–79, to 35 in 1981–86 and 12 in 1987–91 (52). A two-dose policy was adopted in 1989, with MMR given at 15 months and measles alone at age 6 years, with a catch-up of the second dose among schoolchildren, covering 3 additional school grades each year (53).

Gaza, with a population of 642 000 in 1990 (many living in crowded and unsanitary conditions) and a GNP per capita in 1989 of US$ 1316 (increased from $605 in 1975), had a very high measles incidence in the 1970s, with continuing periodic epidemics (Table 2).

Vaccination at 9 months was introduced into the preventive child health programme in Gaza in 1976, with coverage reaching 88% by 1987. Because of the high level of morbidity and mortality from measles in the 1970s and early 1980s, a two-dose measles policy was adopted in 1987, with measles vaccine at 9 months and MMR at 15 months. A catch-up campaign of the second dose of measles was carried out during 1988–91 covering more than 90% of schoolchildren up to age 12 years and preschoolers. As a result, measles incidence came down rapidly to rates similar to those of the Israeli and West Bank populations (52).

A measles epidemic in 1991, which began in a localized outbreak in the West Bank with 236 cases and 1 death, then spread to Bedouins in the Negev with 327 reported cases, 7 deaths, and 163 hospitalizations. The epidemic spread to the Jewish population of Beersheva, with 106 cases, no deaths, and 40 hospitalizations. The epidemic subsided following a widespread measles vaccination programme, and as a result of restricted public activities during the Gulf War of 1991. The epidemic subsequently spread to

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all parts of Israel with some 600 additional cases (57).

In Gaza, few cases of measles were reported in 1991, and none proved to be measles on clinical, epidemiological and serological investigation. The spread of the epidemic to Gaza might have been expected because of close and continuing contact between the Negev Bedouins and the Gaza population. Transmission was probably prevented by the high level of coverage in Gaza with the two-dose schedule which covered children up to 12 years of age. People over 12 were probably protected by high levels of previous measles exposure (57).

**Developing countries**

Measles is a leading cause of childhood morbidity and mortality in developing countries. Furthermore, the residual effects of measles often precipitate other, often fatal illnesses among children. The incidence of illness and death in the months following a measles outbreak can be up to 10 times greater among children who contracted the disease than among those who did not. Measles is also one of the major contributors to childhood malnutrition. These problems continue to plague even developing countries with relatively high coverage (71, 73). We examined the measles experience of three developing countries at different stages of development.

**Philippines.** In 1990 the Philippines had a population of 62.4 million, GNP per capita of US$ 630 (1988), and an infant mortality rate of 44/1000 live births (1989). Primary school enrolment is reported as virtually 100% of school-age children (5, 60).

Measles was among the ten leading diseases in the Philippines in the period 1982–86, with an annual average of 55 459 reported cases, and 81 896 cases reported in 1987 (143/1000 population). Measles was the 4th leading cause of infant deaths between 1982 and 1986, and the 6th leading cause in 1987.

Measles became more prominent as a contributor to the total mortality for all age groups over the period 1967 to 1987. In 1967, measles was not among the 10 leading causes of death in the Philippines, but appeared as the 10th cause in 1977. In the 1982–86 period, measles was the 6th leading cause of death for all age groups, with an annual average of 12 431 deaths (22 per 100 000 population). In 1987, measles was the 8th leading cause of death with 7340 deaths (14 per 100 000). As seen in Table 3, in 1987 measles accounted for approximately 1/6 as many deaths for all age groups as pneumonia, 1/5 as many as diseases of the heart, 1/4 as many as tuberculosis, and 2/5 as many as all malignant neoplasm deaths.

Measles immunization is recommended at 9 months of age. Coverage among 1-year-olds is reported to have increased from 53% in 1985/86, to 77% in 1987/88 and 83% in 1988/89 (5). A second-dose measles programme in the schools would reach a very high percentage of children still susceptible and still serving as vectors for the virus.

**Malawi.** Malawi, in east-central Africa, in 1988/89 had a population of 8.4 million, GNP per capita of US$ 170, an infant mortality rate of 147/1000, and primary school enrolment of 53% for females and 73% for males (1986–88) (5, 60). Measles immunization of 1-year-olds was reported as 65% in 1981, increasing to 78% in 1987/88 and 84% in 1988/89 (5).

Measles was the leading cause of death in the age group 0–4 years in 1983, accounting for 16% of all deaths in hospital. It was the 9th leading cause of

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**Table 2: Average annual incidence of measles in Israel, West Bank, and Gaza, 1968–91**

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<tbody>
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<td><strong>Israel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases (total)</td>
<td>7455</td>
<td>6786</td>
<td>9344</td>
<td>5777</td>
<td>1469</td>
</tr>
<tr>
<td>Average annual number</td>
<td>1491</td>
<td>1359</td>
<td>1869</td>
<td>1157</td>
<td>367</td>
</tr>
<tr>
<td>Average annual ratea</td>
<td>50</td>
<td>39</td>
<td>48</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td><strong>West Bank</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases (total)</td>
<td>2306</td>
<td>757</td>
<td>2174</td>
<td>1629</td>
<td>420</td>
</tr>
<tr>
<td>Average annual number</td>
<td>461</td>
<td>151</td>
<td>435</td>
<td>326</td>
<td>105</td>
</tr>
<tr>
<td>Average annual ratea</td>
<td>77</td>
<td>23</td>
<td>61</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td><strong>Gaza</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases (total)</td>
<td>12 276</td>
<td>2906</td>
<td>2981</td>
<td>1999</td>
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<tr>
<td>Average annual number</td>
<td>2455</td>
<td>581</td>
<td>596</td>
<td>400</td>
<td>71</td>
</tr>
<tr>
<td>Average annual ratea</td>
<td>663</td>
<td>141</td>
<td>130</td>
<td>78</td>
<td>12</td>
</tr>
</tbody>
</table>

* Incidence rate per 100 000 population.
death in children older than 4 years, and the 8th commonest cause for outpatient visits in the 0–4-year age group.\(^9\)

**Nigeria.** Nigeria is the most populous nation in Africa, with a population of 105 million in 1989, a GNP per capita of US$ 290 (1988), infant mortality rate of 102/1000 (1989), and primary school enrolment of 85% for females and 97% for males (60).

The under-5 population forms 21% of the total population, while those aged 16 and below account for 52%. The percentage of children of primary school age enrolled in primary schools in 1986–88 was 64%. The under-5 mortality rate was 170/1000 in 1989 (5).

The main causes of infant and child deaths in Nigeria in 1985 were malaria, vaccine-preventable diseases, diarrhoea, respiratory infections, and malnutrition. In that year, 3.6 million cases of measles were recorded, with 108 000 deaths and 54 000 disabled. The commonest complications were undernutrition, pneumonia and diarrhoea, and the main disabilities were blindness and deafness. Measles accounted for 50% of deaths from vaccine-preventable diseases and 26% of disabilities.

Measles vaccination coverage was reported as 55% in 1981 and 59% in 1988 (5). Coverage of the major target group, children aged 12 months and below, for measles vaccination in 1989 was still 59% despite a sustained seven years’ immunization campaign (58, 59). A second dose of measles given in primary schools would reach large numbers of children not immunized at all and would boost the protective level of those previously immunized.

### Costs/benefits

Both developed and especially developing countries suffer from the problem of limited resources available for their societies in general, and for health needs in particular. Budgetary constraints can provide a serious barrier to the implementation of a second-dose measles programme. Cost-benefit analysis may be essential before promoting a two-dose schedule. Previous cost-benefit studies of measles vaccination were related to a single dose and found high benefit-to-cost ratios (73–78).

We recently carried out a cost-benefit analysis (68) by comparing the existing single-dose vaccination programme at 15 months to a two-dose programme, with the second dose at age 6 years, for Israel, the West Bank and Gaza. The benefit-to-cost ratios were 4.5/1 in Israel, 5.7/1 in the West Bank, and 9.6/1 in Gaza (52, 53).

By adjusting the models’ parameters to the new vaccine cost of $0.42 per dose in 10-ml vials, and adding $0.70 per inoculation for the labour costs of giving the vaccination in a school setting (79), we estimate the break-even incidence rate (where the benefits to society equal the costs to society) of measles to be 3.5 cases per 100 000 population. Considering direct benefits and costs to the health services alone, the break-even incidence rate is approximately 9 per 100 000.

The majority of developed countries provide comprehensive health services and have measles incidence >3.5 per 100 000, as well as a higher level of per capita GNP than Israel, and should therefore consider the implementation of a second measles inoculation. The benefits to their societies will outweigh the costs of the programme.

Higher benefit-to-cost ratios than those found in Israel would be expected in those countries which have higher incidence rates, whether due to higher vaccine failure rates, or for other reasons. The cost-benefit findings from the West Bank and Gaza are more like those relating to developing countries, with lower hospital-bed-to-population ratios, but where, as in the case of Malawi, Nigeria and the Philippines, measles is a predominant cause of hospitalization of children. The benefits from reductions in outpatient services (including medication) may be far lower in developing countries, owing to poor access to such services. However, this reduced benefit may be compensated for by the vaccination having a greater impact in terms of greater reduction in mortality.

### Discussion

Measles immunization of children after one year of age, with a single dose of the current vaccine, has successfully reduced measles incidence in most developed countries by a very large factor. However, measles as a public health problem remains because the disease continues to occur in outbreaks. The optimism surrounding measles eradication by the

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early 1980s has been followed by pessimistic assessments that such eradication is not feasible, at least with continued promotion of the one-dose vaccination policy (23). Clearly demonstrated primary and secondary vaccine failures and the virtual impossibility of obtaining the >95% immunization coverage in infancy, which is currently estimated to be needed for eradication in the foreseeable future in most developing and many developed countries, make absolute measles control a difficult objective. Nevertheless, while eradication may not be attainable in the short term, continuation with the one-dose policy is not justified.

The published data from the countries we examined demonstrate that the problem of measles is still extremely important in both developed and developing countries. In the Quebec and Waterloo outbreaks in Canada in 1990 and 1991, large numbers of high-school and post-high-school students were ill with measles, despite “universal immunization”. Similarly, in the USA, between 1985 and 1989, many epidemics were documented among highly immunized populations. The USA has subsequently adopted a two-dose measles vaccination policy, while Canada continues with the one-dose policy.

In developing countries, measles is a far more serious problem. Most measles-related disabilities, and most of the estimated 1.4 million annual measles-related deaths occur in these countries. The countries we examined represent different levels of development in different parts of the world, with high measles morbidity and mortality despite great efforts to develop effective immunization programmes during infancy. International organizations such as WHO and UNICEF (73) currently recommend vaccination of infants at 6–9 months because of the high susceptibility of young infants to measles and its complications. Thus, many children are immunized while maternal antibodies are still present at sufficient levels to prevent an adequate response to the vaccine, resulting in high percentages of vaccine failure, with low levels of individual protection and herd immunity. Where early vaccination is indicated by the epidemiological situation (high morbidity and mortality in infancy), a second dose should be seen as essential to boost the immunity levels and catch those who did not get the primary vaccination. The second dose administered in the primary school setting would be an efficient way to cover this age group of still susceptible children.

Some developed countries have adopted a two-dose measles policy, the arguments in favour of which include the difficulty in securing sufficiently high coverage in infant populations to achieve complete herd immunity, primary and secondary vaccine failures, and the continued occurrence of epidemics in school-age populations with high vaccination coverage. These factors apply even more to developing countries where the epidemiological patterns of measles are altered under the impact of increasing vaccination coverage.

Despite impressive increases in immunization coverage of infants in developing countries, the rates are still lower than in developed countries, with many unvaccinated children entering the primary schools. Second-dose immunization of schoolchildren could significantly increase the level of herd immunity in developing countries where primary school attendance is widespread and often mandatory; for example, enrolments are reported at virtually 100% in the Philippines, and 64–66% in Malawi and Nigeria (5). Vaccination of school-age children lends itself to mass campaign logistics and can be coupled with DPT immunization and poliomyelitis’ control activities, so that the additional costs are primarily for the measles vaccine.

Though perhaps not recognized as a priority because of lower case-fatality rates among older children, school epidemics occur in developing countries. These are likely to increase, as high immunization coverage shifts the disease to an older age group, as occurred in the developed world (4, 62–68). Measles outbreaks in schools have been documented in Lesotho, Swaziland, Burundi and Rwanda, among others. Although measles in schoolchildren causes less mortality than among infants, the morbidity and mortality in this age group is still important, as seen in the data from the Philippines. Furthermore, this population group can serve as the vector to spread the disease to the preschool-age population through sibling infection, so that a school-age measles vaccination programme will help reduce the circulation of the measles virus. Secondary spread of measles from epidemics beginning in schools has been shown to be greater than when the primary case is a child under 5 years of age (25, 27, 62). The one-dose policy, aimed at the infant population, is not sufficient to address this problem, even with the new high-dose Edmonston-Zagreb vaccine (69–72).

Favourable benefit-to-cost ratios of the two-dose policy in Israel, the West Bank and Gaza, adjusted to current vaccine prices, have been noted, with measles incidence rates as low as 3.5/100 000 population (all health and social costs being included) and with rates of 9/100 000 when only direct health services costs were included. The benefit-to-cost (B/C) ratio for a two-dose policy varies with the incidence and complication rates of the disease and with many economic indicators in a particular country, but in a study of a number of developed and
developing countries, the benefits outweigh the costs by large margins. The ratio for the United Kingdom was found to be 38.6/1 for health services alone, and 86.3/1 for society as a whole. For Italy, the B/C ratios were calculated as 20/1 for health services and 53/1 for society as a whole, and for Canada they were 17/1 and 8/1 for health services and for society respectively (79). These calculations also apply to developing countries where the health costs of measles cases may be less, but the morbidity rates are higher than in developed countries (53, 73–78, 80).

The Pan American Health Organization’s programme to eliminate indigenous transmission of measles in the English-speaking countries of the Caribbean is based on achieving and maintaining immunization coverage with MMR for at least 95% of children aged 12–15 months, and interruption of transmission among older susceptible persons by immunizing all under-15-year-olds regardless of their history of vaccination or reported measles infection, as well as effective outbreak identification and control measures. This policy takes into account possible prior deficiencies in the cold chain, in previous coverage, in vaccine efficacy/vaccine failure, and in clinical or laboratory diagnostic errors (81).


Conclusions

Adoption of the two-dose measles vaccination policy during the 1990s for both developed and developing countries will greatly speed up measles control, and save much preventable disease, disability and death over the decades ahead. The case for action is strong and adoption of the two-dose policy on an international scale is overdue.

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Résumé

La lutte antirougeoleuse dans les pays développés et en développement: arguments en faveur d’une politique de vaccination en deux doses

La rougeole reste une des grandes maladies infectieuses infantiles à l’origine de nombreux décès et incapacités. Elle pose des problèmes, d’ampleur différente il est vrai, aussi bien dans les pays développés que dans les pays en développement. La vaccination en une dose unique généralement préconisée n’a pas permis de lutter efficacement contre cette maladie, ni de l’éradiquer, même dans les régions les plus développées du monde. La politique vaccinale en deux doses introduite dans certains pays présente des avantages importants puisqu’elle permet d’atteindre les enfants n’ayant pas été vaccinés dans leur petite enfance, et de réduire le nombre de cas dus à des échecs vaccinaux primaires et secondaires.

Nous analysons ici l’expérience d’un certain nombre de pays développés d’Europe et d’Amérique du Nord, et de pays en développement tels que le Nigéria, le Malawi et les Philippines, ainsi que la Cisjordanie et la bande de Gaza. Ce sont des exemples de populations qui présentent différents niveaux de développement. Nous sommes en faveur d’une politique de vaccination en deux doses comprenant une dose de rappel au cours de la scolarité, s’ajoutant à une couverture maximale des nourrissons entre 9 et 15 mois. Des campagnes de rattrapage pourraient être effectuées chez les enfants d’âge scolaire jusqu’à ce que la politique vaccinale en deux doses puisse être effective. Une politique plus “agressive” permettrait d’éviter une morbidité et une mortalité inutiles en reconnaissant les limites des vaccins, de la couverture et des stratégies de lutte actuelles.

Une analyse coût/avantages a montré qu’une politique de vaccination en deux doses est économiquement préférable dans les pays développés et dans certaines régions en développement. La rougeole est une maladie évitable, mais pour la combattre le plus efficacement possible et parvenir à l’éradiquer, il faut de nouvelles stratégies et une volonté renouvelée d’améliorer la protection des individus et l’immunité collective. La stratégie préconisant une vaccination en deux doses est en mesure d’y parvenir et représente une politique de santé publique appropriée pour les pays développés comme pour les pays en développement.
Measles control: the case for a two-dose policy

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