The Expanded Programme on Immunization in the European Region of WHO

Measles

A strategic framework for the elimination of measles in the European Region

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A strategic framework for the elimination of measles in the European Region

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European HEALTH21 target 7

EUROPEAN HEALTH21 TARGET 7

REDUCING COMMUNICABLE DISEASES

By the year 2020, the adverse health effects of communicable diseases should be substantially diminished through systematically applied programmes to eradicate, eliminate or control infectious diseases of public health importance

(Adopted by the WHO Regional Committee for Europe at its forty-eighth session, Copenhagen, September 1998)

Keywords

MEASLES – prevention and control
STRATEGIC PLANNING
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Foreword

The European Advisory Group on Immunization (EAG) commissioned in 1997 the preparation of a framework for the elimination of measles from the WHO European Region. The strategic plan for measles elimination was considered at the Thirteenth EAG in March 1997 and endorsed at the Programme Managers' Meeting in November 1997.

The EAG was convinced that the elimination strategy, which is based on the identification of susceptibility, was the most appropriate approach for the Region. It was agreed that the target date for elimination should be set at 2007 but that this could be brought forward, especially if some western European countries, where measles control is presently of low political priority, made a full commitment to elimination.

The measles elimination strategic plan was endorsed as one of the targets for health for all in the 21st century (HEALTH21) and was therefore approved by the Regional Committee.

It is hoped that this document will alert decision makers to the cost–effectiveness of implementing additional activities to achieve measles elimination and generate the assistance and support of national and international agencies.

I would like to express my gratitude to the colleagues of the PHLS Communicable Disease Surveillance Centre, London, namely Dr Mary Ramsay and Mr Nigel Gay for their valuable contributions to this document. I would also like to thank Mr Philippe Beutels of the University of Antwerp for his assistance in developing an economic model. Finally the steering group, which reviewed the plan of operation and its regional feasibility in March 1998, should be thanked.

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A STRATEGIC FRAMEWORK FOR THE ELIMINATION OF MEASLES IN THE EUROPEAN REGION

Introduction

The World Health Organization has made tremendous efforts towards the global eradication of wild poliovirus by the year 2000. The novel approach used to achieve this success, was the National Immunization Day, where live attenuated polio vaccine is delivered to a high proportion of the childhood population on a single day.[1] Using this strategy, countries which were recently endemic for poliomyelitis have successfully interrupted the transmission of wild poliovirus. After the global eradication of polio is achieved, vaccination efforts will naturally turn towards the other EPI diseases, and in particular to measles.

Until recent years, the main objective of EPI measles vaccination was to reduce the considerable morbidity and mortality attributable to measles infection. In the European Region the specific targets are that by the year 2000:

- there should be no deaths from indigenously acquired acute measles in the Region; and
- the annual incidence of confirmed measles in each country of the Region should be less than 1 per 100 000 population.

The main strategy recommended is the routine provision of a single dose of measles vaccine and the achievement of high vaccine coverage. Recent experience in the Americas has indicated, however, that by using the mass campaign approach developed for polio eradication, the transmission of measles infection can also be interrupted.[2,3] These successes have indicated, therefore, that the eradication of measles is achievable.

Justification for elimination of measles in Europe

In the absence of vaccination, almost all children acquire measles infection before the age of 15 years.[4] The complications of measles include diarrhoea, encephalitis, otitis media, pneumonia and death.[4,5,6] It has been estimated that, even with a global vaccine coverage of 80%, measles infection kills about 1 million children each year, mainly in developing countries.[7] The case-fatality ratio for measles infection is greatest in malnourished children, in secondary cases, and when the infection is acquired under the age of one year[8] or over the age of 10 years.[9] In developed countries, the numbers of deaths and complications associated with measles infection has fallen since the first half of the century, mainly due to improved nutritional status and smaller family size. Despite this fall in the mortality and morbidity associated with measles infection, the disease incurs substantial health care costs.[10] Measles vaccination programmes can therefore produce a net cost saving in developed countries.[11,12,13,14,15]

For these reasons the Expert Advisory Group for the European Region has commissioned the preparation of a framework for the elimination of measles from the Region. The aims of this strategy will be to:

- to further reduce the morbidity and mortality from measles in the European Region;
- to eliminate indigenous measles from the European Region by the year 2007.

Current status of measles control

Vaccine policy

The European Region of the WHO comprises 51 Member States. During 1996, a questionnaire was sent to all countries to establish current and past vaccination policies and the status of measles control. Responses were received from 41/50 countries which represent 90% of the population of the Region (Annex 1). Virtually all countries have been using a live attenuated measles vaccine for routine vaccination since 1980 or before. All but two countries deliver the first dose of vaccine between 12 and 18 months of age; the remaining two use the first dose of vaccine at 9 months of age. Thirty-eight of the 41 countries have a second dose of vaccine given at between 3 and 14 years of age. Fourteen countries have performed supplemental national vaccination campaigns since the introduction of routine vaccination.

Vaccine coverage

Regional coverage for the first dose of measles vaccine increased during the 1970s and 1980s and has reached 82% and remained stable during the 1990s. Only seven countries have managed to sustain coverage of 95% over the most recent five year period for which data was available; another fourteen countries have sustained over 90%. Of the remaining 20 countries, eight have coverage over 80%, nine between 50% and 80% and three have coverage consistently below 50%.

Disease surveillance

Thirty-four countries have national reporting of measles cases and 15 are able to perform laboratory confirmation of cases. These reporting systems vary enormously in there completeness, timeliness and in the data collected. Despite these reservations, during 1995 the average incidence of reported measles in the Region was 7 per 100 000 population; which had fallen from a rate of 43/100 000 in 1987. Deaths from measles have fallen from a total of almost 2000 in 1970 to less than 150 in 1993.

The data collected suggest that in many countries, measles vaccination has had a positive impact on the incidence of measles infection and a dramatic impact upon the numbers of deaths. In a few countries, very high coverage has been achieved and the incidence of measles has fallen below the target level of 1 per 100 000 population. Despite these successes, many other countries are failing to reach the operational targets established by the WHO European Region.

With few exceptions, failure to achieve operational targets in this Region is not due to lack of resources but due to poor commitment to the goal of measles control. Realization of the goal of measles elimination in the Region will therefore require a process of re-defining the public health priorities and the engineering of a major shift in current policies and practices.

POTENTIAL STRATEGIES FOR ACHIEVING MEASLES ELIMINATION IN THE EUROPEAN REGION

Maintaining high routine coverage of a single dose of vaccine

This is the strategy previously recommended by the WHO and implemented in most countries in the European Region by the late 1970s. This approach can control measles and reduce the substantial morbidity and mortality associated with the disease.

With low coverage (<90%) measles will continue to circulate and epidemics will occur, usually every three or four years. The size of the epidemics will be small by pre-vaccination standards and major reductions in the numbers of cases and deaths are feasible with coverage below 90%.[16]

Achieving high coverage with a single dose can produce prolonged periods of freedom from measles. The period when high coverage has been achieved and when good control has been maintained for some years is known as the "honeymoon period". Following a period of variable length, however, it is inevitable that cohorts of susceptible persons (those who did not receive vaccine or those who failed to respond to a single dose of vaccine) will accumulate and therefore epidemics of measles will occur, predominantly amongst older children.[17,18] Although the size of these epidemics may be small by pre-vaccine standards, they may be associated with a higher case-fatality among adolescents,[9] and the costs of outbreak control and investigation may be large. In addition, they may cause a loss of confidence in the vaccination programme as many of the cases will occur in children who have been previously vaccinated.[18] To maintain control with a single dose, efforts must be also be made to maximize vaccine coverage and to target and mop-up pockets of low vaccine coverage which could act as a focus for the introduction of measles into the general population.

Two dose schedules

The use of a second dose of a measles containing vaccine can improve measles control and some countries have managed to interrupt measles transmission by achieving high vaccination coverage for both dose.[19,20,21,22] The second dose offers a second opportunity for vaccinating children who were not vaccinated, and a second chance to protect those children who fail to sero-convert following a single dose of vaccine (primary vaccine failures). Although primary vaccine failures represent less than 10% of children immunized above the age of 12 months,[23,24] experience has shown that with high single dose coverage these children can contribute to the maintenance of measles transmission.[18] By using a second dose of vaccine, the accumulation of susceptibles can be slowed and the "honeymoon" period prolonged.

To achieve the maximum effect with a two dose schedule, however, coverage of both the first and the second dose must be high. A two dose strategy is unlikely to be effective when the coverage of the first dose is low:[7,18] from compliance patterns observed with other vaccines, it is to be expected that persons who receive a first dose of vaccine are more likely to receive the second dose than those who have not previously been vaccinated.[25,26] In addition, for a two dose schedule to reduce the accumulation of susceptibles, the second dose should be given shortly after the first – ideally before the person enters school. If given above this age the cohorts of susceptible children enter a setting where transmission of measles is facilitated and the possibility of school outbreaks occurs.[27]

A two dose schedule also has the potential to prevent accumulation of susceptibles by preventing the waning of vaccine-induced immunity (secondary vaccine failure). As the role of secondary failures is probably small[28] this is not a major reason for recommending a two dose schedule.

Mass "catch-up" campaigns

The difficulties of maintaining high coverage rates[1] and the problems of outbreaks occurring in older children has prompted the use of novel strategies for delivery of measles vaccine.[2] This strategy involves the use of a mass "catch-up" campaign, targeted "mop-up" campaigns in low coverage groups and periodic "follow up" campaigns. Cuba commenced such strategy in 1986 and has succeeded in interrupting the transmission of measles.[3] During the campaign all children aged 1–14 years were offered vaccination, regardless of previous vaccination status. By the concentration of efforts on a single campaign, high coverage can be achieved, even in groups which may have difficulty accessing routine vaccination services.[2] Similar campaigns have now been conducted in Chile, the English speaking Caribbean countries and in other countries in Latin America.[3]

Mass campaigns such as these will accelerate measles control by the rapid reduction in the proportion of susceptible persons and can therefore be used to avert a threatened epidemic.[27] Although many European countries have performed catch-up vaccination campaigns, only one country has attempted this kind of programme to prevent a predicted outbreak. In November 1994, all children aged 5–16 years in the United Kingdom were offered measles-rubella vaccine.[9] Coverage of 92% was achieved, the proportion of the target age group who remained susceptible to measles was rapidly reduced and control of measles accelerated.[29]

Following a campaign, however, new cohorts of susceptible children will continue to accumulate.[3] To slow this accumulation, efforts must continue to maintain or improve coverage of the first dose of vaccine. In addition, because of the small proportion of children who fail to respond to a single dose (primary vaccine failures), mass campaigns will need to be repeated or a routine second dose of vaccine introduced to prevent future outbreaks.

PROPOSED STRATEGY

The specific objectives of the strategy will be:

1. to reduce the estimated proportion of measles susceptibles in the population to low levels by the year 2005;
2. to maintain these low levels of susceptibility until 2007.

The proportion of susceptibles in each age group must not exceed 15% in children aged 1–4 years, 10% in 5–9 years olds, 5% in 10–14 year olds, and 5% in each cohort of adults above this age. These levels are those felt to be sufficient to interrupt measles transmission (Annex 2). Achievement of these levels and the elimination of measles in the European Region will therefore depend upon **all** countries in the Region undertaking the following programmes:

1. Establishing the political commitment to measles elimination

Many countries have made substantial efforts to control measles, to achieve high levels of coverage and, despite recent difficulties in some states, are nearing elimination. In other countries, coverage of measles vaccine has always been low and control of measles is worse than in many developing countries. This does not reflect lack of resources, as high coverage is often achieved for other vaccines, but reflects the professional and public perception of measles as a mild disease. Some of these countries are using valuable health care resources to offer a second dose of vaccine, where more effective control could be achieved by improving coverage of the first dose. Within each country, public health professionals must develop the evidence required to reorientate public and professional opinion. Educational material for health care professionals should be developed on the basis of sound surveillance data. Data should be collated and used to demonstrate the impact of measles infection in each country. Formal cost benefit analyses may be required to persuade policy makers of the potential value of measles elimination. Many of these countries have devolved vaccination services provided by private practitioners. In these situations, efforts must be made to involve key professionals and to access professional organizations. By this means private practitioners can be persuaded to help with provision of vaccination services and to contribute to surveillance information.

2. Developing a measles elimination plan based upon an assessment of the local epidemiology

Having established the political commitment to measles elimination each country should establish a detailed implementation plan, identifying the surveillance needs and the potential strategies. Appropriate strategies should be decided upon the basis of accurate surveillance data.

The main tasks and the initial approaches required are outlined for three broad groups of countries in the next section. On the basis of the current level of measles control, the Region can be divided into three groups (Annex 3). These categories are based upon the demonstration of good control by adequate surveillance and upon the levels of susceptibility required to interrupt measles transmission and to maintain elimination (see Annex 3). Countries should identify the group in which they fall and review the necessary tasks within their plan. The initial approaches required will vary between groups, and countries should follow the appropriate strategy until indicators of measles control change and that country enters into another category. A change of

approach must be based only upon accurate surveillance data and surveillance therefore forms the key to implementation of the strategy within each country.

3. Achieving and maintaining high routine immunization coverage for the first dose of measles vaccine, and ensuring high coverage in all geopolitical units

Countries will need to identify the reasons for poor coverage in their own country. In only a few countries will this relate to sustainability of vaccine supply or poor structures for delivery of vaccination services. In most countries, surveys of parental and professional knowledge, attitude and practices may be required to identify whether poor coverage relates to the perceptions of the disease or to concern about vaccine safety. Studies may be required to identify missed opportunities for immunization or the application of false contra-indications by health care staff. Identifying the specific problems in low coverage groups (such as ethnic minorities or refugees) is also important. This may reflect cultural attitudes to vaccination or these groups may not have access to health care services.

Having identified the problems and causes of poor coverage, the country must implement new programmes for improving coverage. These may include securing vaccine supply and improving the infrastructure for delivery of immunization services. The provision of opportunistic vaccination (in health care settings), or domiciliary vaccination (with health care staff going from house to house) may be required. In other countries, the provision of research-based health education programmes, or the improved training of health care staff is required. Any new programmes should be monitored and the impact on knowledge, attitudes and practice must be evaluated in addition to measuring the effect upon vaccination coverage.

4. Strengthening the surveillance of measles

Surveillance of measles must be strengthened in all countries by:

- monitoring measles vaccination coverage.

The age-specific vaccination coverage for one (and two doses when used) should be measured in each geopolitical unit. This will allow the identification of any pockets of low coverage, encourage efforts to improve coverage and enable the early detection of any falls in coverage. Methods for obtaining measures of vaccination coverage vary, as does the accuracy of information produced. To estimate the current proportion of susceptibles and therefore to choose the correct strategy, those countries using proxy measures such as numbers of doses distributed to clinics, must validate their coverage estimates by ad hoc surveys (for example using the WHO cluster sampling method). An alternative or supplemental approach may be to perform serological surveillance. All countries should regularly assess the accuracy of coverage data.

- Instituting or continuing the national statutory reporting of suspected measles.

Data on measles cases should be collected on a weekly or monthly basis from all geopolitical units. The five countries without a national notification system should develop alternative models based on voluntary or sentinel surveillance, laboratory reporting, or hospital admissions in the interim. Other countries should develop their current system to collect information on age, geographical location and vaccination status of cases.

- Use of a standard case definition.

Where possible cases reporting should be based upon a sensitive case definition and this case definition may used to select any cases for laboratory testing. An appropriate case definition may

be the WHO definition of: “any person with: generalized maculopapular rash (i.e. non-vesicular), *and* history of fever of 38 °C or more (if not measured “hot” to touch) *and* at least one of the following: cough, coryza (i.e. runny nose) or conjunctivitis; *or* any person in whom a health professional suspects measles.

- Establishing the laboratory resources to assist with measles surveillance tasks.
- Laboratory confirmation will be particularly important as measles incidence declines. Laboratory support will be required to perform confirmation of diagnosis, to attempt virus isolation on clinical specimens and to assist with serological surveillance if required.

Once this support is established these laboratories can be used to monitor the number of laboratory tests performed and the number of cases confirmed. As measles incidence declines cases of non-measles rash and fever illness will become relatively more common. To be confident of measles elimination will require laboratory investigation to be conducted on a high proportion of such cases. Therefore as control improves the proportion of suspected cases confirmed as measles will fall. As elimination nears it will be important that adequate numbers of suspected cases are tested, and the rate of testing required will depend upon the baseline incidence rate of non-measles rash and fever illness. This rate may vary between countries and over time.

- Instituting regular analysis and feedback of surveillance and coverage data.

The number of cases reported should be analysed by time, by location and, where possible, by person (age, vaccination status) and compare this to vaccination coverage in these groups. Analysis of the completeness and timeliness of surveillance reports should also be conducted. Effective surveillance depends upon the feedback of data to those who provide it. This encourages better reporting and will allow the prompt planning and implementation of any local control measures.

5. Estimating the age-specific proportion of the population who are susceptible to measles

To predict the potential for future outbreaks, the likely achievement of elimination and to inform the correct vaccination strategy requires an estimate to be made of the age-specific proportion of the population who are susceptible to measles. This can be obtained by performing serological surveys or can be estimated by mathematical modelling using accurate surveillance data. Modelling on the basis of inaccurate coverage or disease incidence data may lead to errors in the predictions of future outbreaks, the choice of inappropriate strategies and ultimately in the failure to achieve measles elimination.

As it is recognized that serological surveillance is not feasible in all states, countries may be able to predict the age-specific proportion of susceptibles in the population by mathematical modelling based on vaccination coverage data and/or age-specific disease incidence. Such modelling may also be used to inform future strategy by predicting the effects of alternative programmes. A series of illustrative case studies have been drawn up to demonstrate the potential usefulness of this approach.

6. Choosing an appropriate strategy to accelerate measles control

Based upon vaccine coverage, surveillance data and the estimate of the age-specific proportion of the population susceptible to measles the appropriate strategy to accelerate measles control must

be chosen. In addition to the maintaining or improving first dose vaccine coverage, strategies to accelerate measles control may include the use of mass “catch-up” campaigns and/or the routine use of second dose of vaccine. The appropriate strategy will depend upon the current level of control, the predicted level of susceptibles, and the time frame for implementation.

In addition, factors that will be taken into account will include the costs of delivery of various vaccination programmes, the acceptability of such delivery methods and the accessibility of the population. To aid countries in the choice of strategy a series of cost-effectiveness models will be constructed based upon scenarios which are representative of countries at different levels of measles control. The models will examine the relative cost-effectiveness of various options for accelerating measles control compared to continuation of the current strategy. It is hoped that these illustrative examples will allow countries to choose the most appropriate strategy.

7. Choosing an appropriate strategy to maintain measles elimination

An important aspect of the elimination strategy is the ability of each country to maintain the proportion of susceptibles below target levels. This will be required to prevent transmission becoming re-established following the introduction of measles into a population from a neighbouring country or from outside the Region. Based on vaccine coverage, surveillance data and the estimate of the age-specific proportion of the population susceptible to measles a choice of strategy to maintain measles elimination is required. This strategy, in addition to the maintenance of high first dose vaccine coverage will include either the intermittent use of mass “catch-up” campaigns and/or the routine use of second dose of vaccine and high coverage will be required with either strategy. The timing of the required campaigns can be predicted based upon the estimate of the proportion of the population who are susceptible.

Regional initiatives

Many countries in this Region have advanced facilities for laboratory diagnosis that are already contributing valuable surveillance data. As more countries participate in laboratory based surveillance, however, it will be important to ensure consistency and comparability between countries. At a regional level it will be important to establish the support for a laboratory network that will allow standardization of methods for the following three laboratory based tasks:

Serological surveillance

If countries decide to perform serological surveys to inform measles strategy, it will be important to maximize consistency and comparability between survey findings. This can be promoted via the laboratory network by the evaluation and approval of appropriate test kits; by the provision of standard sera etc. In addition a quality assurance exercise can be coordinated by a lead laboratory.

Confirmatory testing of cases of measles

As measles infection becomes less common the predictive value of routinely available laboratory tests will be low[30] and the use of specific IgM tests or a multiple testing algorithm may be required. Accreditation and proficiency testing of laboratories performing this confirmatory testing is required. Evaluation and approval of specific IgM test kits and a provision of a standard protocol for their use is recommended.

Isolation and characterization of strains from confirmed cases of measles

This approach can be used to identify sources of importation, to establish links between cases and to indicate continued transmission. Molecular based typing methods can be performed on virus isolates or on products of a PCR used directly on clinical specimens. Standardization of methods and/or establishment of a regional resource to perform this typing is recommended. A regional bank should be established to store strains and samples from confirmed cases.

PHASING IN OF MEASLES ELIMINATION STRATEGIES: STRATEGIC APPROACHES WITHIN EACH GROUP

Group 1: Countries close to elimination

These countries have had excellent vaccination programmes and will have already interrupted measles transmission. Such countries are already committed to the goal of measles elimination. Efforts are required to maintain their excellent performance and to establish the surveillance methods which can confirm elimination. Surveillance data will also be generated which will establish the baseline criteria used to evaluate the surveillance of measles in other countries in the Region as they too near elimination.

Tasks

1. Determine and monitor the age-specific vaccination coverage for one and two doses in each district.
2. Improve vaccination coverage of first dose in any low coverage populations.
3. Strengthen disease surveillance:
    - continue the national reporting of suspected measles using the WHO case definition;
    - encourage active surveillance or case finding via paediatricians, death certificates, hospital discharge review, etc;
    - perform laboratory testing on a high proportion of sporadic suspected measles cases which fulfil the clinical case definition;
    - monitor the numbers of cases tested and the number confirmed to establish baseline rates of non-measles rash and fever illness;
    - collect epidemiological information on confirmed cases (age, vaccination status, geographical location, contact with other cases, travel overseas);
    - collect samples for virus isolation (or for PCR-based detection of viral antigen) in confirmed cases;
    - perform regular evaluation of the accuracy, timeliness, and completeness of surveillance;
    - establish regular, timely feedback of surveillance and coverage data.
4. Maintain high coverage of the first and second dose.
5. Estimate the age-specific proportion of the population who are susceptible to measles by:
    - performing a serological survey; or
    - mathematical modelling using accurate surveillance and coverage data.
6. Use this approach to inform future strategies which may include:
    - reducing the age of the second dose of vaccine;
    - a mass catch-up campaign in older children or young adults;
    - targeted campaigns in groups at risk;
    - continuation of current policies.

7. Establish one or more reference laboratories which will perform confirmatory testing on any cases of measles confirmed in peripheral laboratories.
8. Collect specimens and virus strains from confirmed cases in a single laboratory to contribute to a regional typing bank.

Group 2: Countries with good control but potential for future outbreaks

These countries have achieved remarkable success in measles control. Additional strategies have either not yet been effectively implemented, or have been implemented relatively recently. For this reason these countries may still have groups of the population at risk of outbreaks. With improved surveillance and consolidation of the existing vaccination programmes, many countries in this group may move into group one within a short period.

Tasks

1. Determine and monitor the age-specific vaccination coverage for the first dose in each district.
2. Improve vaccination coverage of first dose.
3. Strengthen disease surveillance:
    - continue national reporting of suspected measles according to the WHO case definition;
    - collect epidemiological information on cases (age, geographical location, vaccination status);
    - identify one or more laboratories with the ability to confirm cases and to isolate virus (or detect viral antigen);
    - perform laboratory confirmation on a high proportion of suspected cases which fulfil the clinical case definition;
    - establish a method to monitor the numbers of cases tested and confirmed;
    - establish regular, timely feedback of surveillance data;
    - perform regular evaluation of the accuracy, timeliness, and completeness of surveillance.
4. Estimate the age-specific proportion of the population who are susceptible to measles by:
    - performing a serological survey; or
    - mathematical modelling using accurate surveillance data.
5. Use this approach to predict future outbreaks and to choose a future strategy to prevent such outbreaks:
    - a “catch-up” campaign; and/or
    - implementation of a routine second dose of vaccine.
6. Repeat this approach to inform future strategies to maintain measles control and achieve elimination by:
    - routine use of a second dose; and/or
    - further intermittent campaigns.

7. Collect specimens and virus strains from confirmed cases to contribute to a regional bank.

Group 3: Countries with poor control

Countries in this group fall into two main categories:

- those where commitment to measles control is poor and surveillance of measles is poor or absent. Decisions to introduce a two dose schedule may have been made at low levels of first dose coverage and without the benefit of appropriate surveillance data. Public health authorities in these countries need to demonstrate to policy makers, health care professions and the public that improving measles vaccination coverage and the acceleration of measles control has the potential to prevent substantial morbidity and that it is likely to prove cost-beneficial. This can only be performed by establishing adequate surveillance.
- those where socioeconomic circumstances are difficult, particularly following recent political unrest or conflict. These countries may have difficulty securing vaccine supply and delivering vaccination and may be using measles vaccine under the age of 12 months. In this setting, a mass campaign approach may be the best means for accelerating and maintaining measles control. Although the infrastructure for surveillance may have been destroyed, these countries will have established AFP surveillance and there is an opportunity to implement measles surveillance using the same systems.

Tasks

1. Determine and monitor the age-specific vaccination coverage for the first dose of vaccine.
2. Improve vaccination coverage of first dose.
3. Strengthen disease surveillance.
    - institute or continue national reporting of suspected measles (if possible using WHO case definition);
    - collect epidemiological information on cases (age, vaccination status, geographical location);
    - establish a laboratory resource with ability to confirm cases and to isolate measles virus;
    - establish regular, timely feedback of surveillance data;
    - perform regular evaluation of the accuracy, timeliness, and completeness of surveillance.
4. Estimate the age-specific proportion of the population who are susceptible to measles by
    - performing a serological survey; and/or
    - mathematical modelling using accurate surveillance data.
5. Use this approach to choose the target population for one or more mass “catch-up” campaigns. Ideally coincide this campaign with acceleration of efforts in neighbouring countries.
6. Repeat this approach to inform future strategies to maintain measles control and to achieve elimination by:
    - raising the age of first dose vaccination to 12 months of age and/or;
    - routine use of a second dose; and/or
    - planning of further intermittent mass campaigns.
7. Collect specimens and virus strains from confirmed cases to contribute to a regional bank.

MONITORING THE STRATEGY

The following targets are proposed for monitoring the implementation of the elimination strategy:

1. Each country to have a measles elimination plan endorsed by the national committee by 2000.
2. Each country to provide annual data to WHO for categorization into the appropriate group by the year 1997.
3. Each country to have achieved 95% coverage for first dose of measles vaccine with coverage >90% in all geopolitical units by the year 2000.
4. National statutory reporting of suspected measles to be instituted in all states by the year 2000.
5. At least one laboratory in each country is established with the ability to confirm suspected measles cases by the year 2000.
6. Each country to have estimated the age-specific proportion of susceptible individuals by age by 2000.
7. Group one countries (close to elimination) to have established an acceptable minimal rate for laboratory tests performed on cases of suspected measles (based on the underlying rate of non-measles rash and fever illness) by the year 2000.
8. All countries to have established and to be performing laboratory testing of sporadic suspected measles cases by 2003.
9. All countries to have planned or implemented additional strategies to accelerate measles control (the use of mass “catch-up” campaigns or the by a routine use of second dose of vaccine) by the year 2003.

Measles elimination in the European Region

WHO
Regional Office for Europe

Material and methods

- Questionnaire in english and russian
- to all 50 member states
- Data entry and analysis
- Results

Questionnaire (1)

- Strategies : strains, year of introduction
- Distribution : private /public
- Coverage since 1970
  1st and 2nd dose
- Epidemiology : surveillance system
  morbidity, mortality
  age distribution
  seasonality

Questionnaire (2)

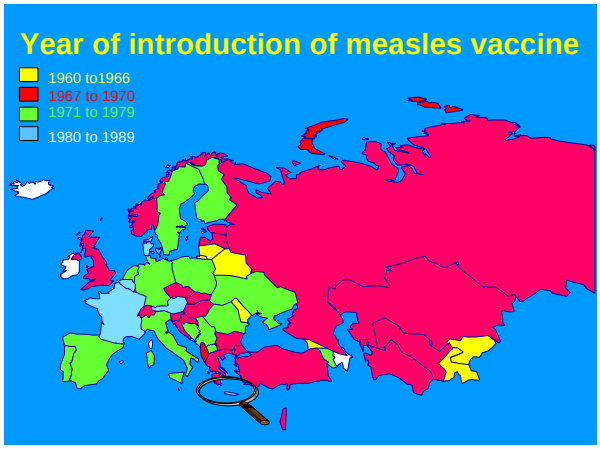
- Serology : lab. tests used
  routine, surveys
- Outbreak : investigation
  control measures
- Evaluation of burden of measles
  vaccine cost, hospitalization..
- National strategy for elimination

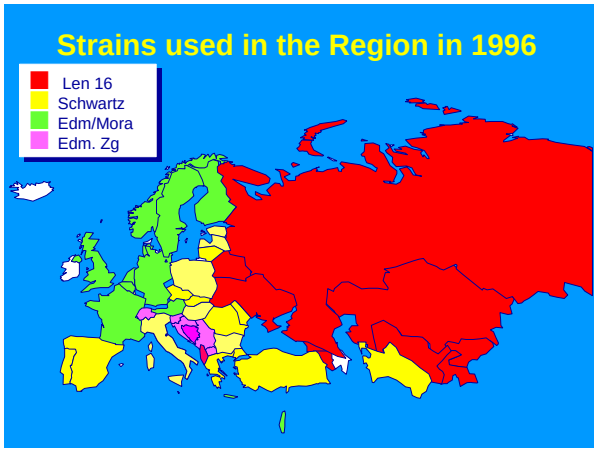
Results

- 44 countries over 50 have returned the questionnaire,
- that represents **98%** of the total population of the Region
- the quality of data varies from countries

Strategies :

- Strains , year of introduction
- Routine strategy
- Specific strategies





Specific strategies

17 countries over 41 use specific strategies to control measles:

- catch up at various age group (10)
- Mass campaigns (2)
- Outbreak response (3)
- Revaccination specific age groups (4)

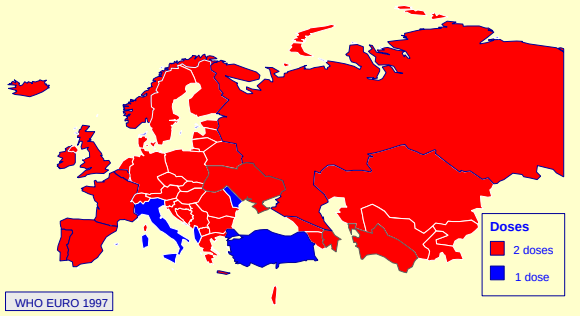
Strategies : national mass campaigns

- 14 countries have performed national mass campaigns since the introduction of the measles vaccination
- 1968 to 1980, 7 countries have performed campaigns at different age groups with L 16 strain
- 1970 to 1994, 7 countries have performed campaigns with Schwartz or Edmonston strains

Routine immunization schedule

- the first dose is given in 41 countries between 9 months and 18 months of age
- Only Tadjikistan and Turkey are implementing it at 9 months of age
- the second dose is given in 38 countries between 3 years and 14 years of age

Measles Immunization schedules in 1997

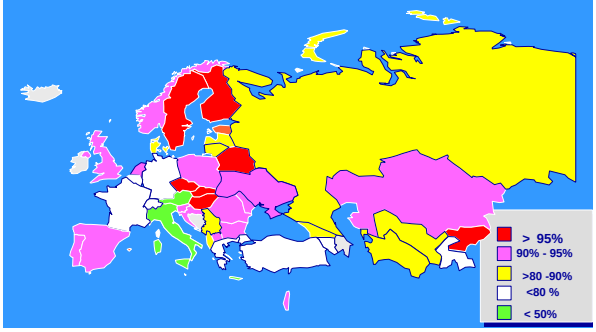


Distribution of immunization

	100%	95- 50%	<50%
Public	19		5
Private	1	6	

Not available information in 13 countries

Measles coverage sustainability for a period of 5 consecutive years, with the 1st dose



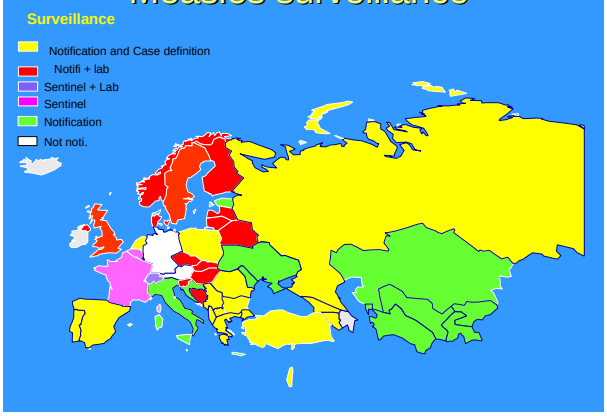
Coverage

- 7 countries have >95% coverage
- 16 countries between 90% and 95%
- 9 countries between 80% and 90%
- 9 countries between 80% and 50%
- 3 countries less than 50%

Coverage (2)

- The first dose coverage since 1970 has slowly increased to reach a plateau of 82% since the 90s
- The second dose reaches an average of 88% for the last 5 years

Measles surveillance



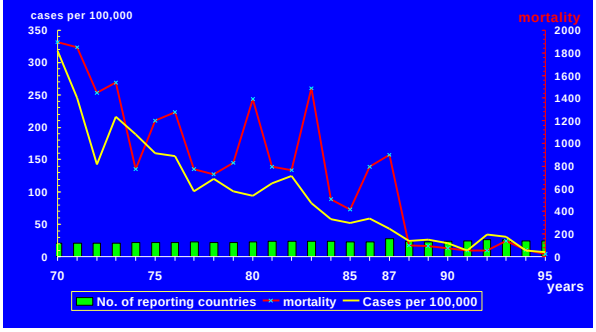
Epidemiology: surveillance

	Yes	No	Not Ap.
Notification	34 :17 w 19 m	5	2
Case defin.	22	5	14
Laboratory	15	17	9
Virol. isol.	21	9	10

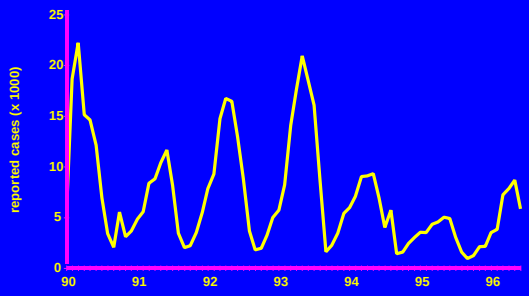
Morbidity and mortality

- **incidence**
- **seasonality**

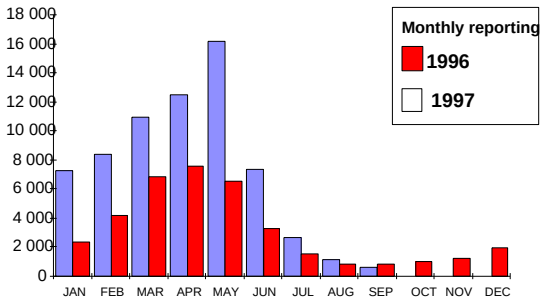
Total number of measles cases and deaths
as reported from 1970-1995



Reported Measles Cases in Europe, 1990-1996, per month

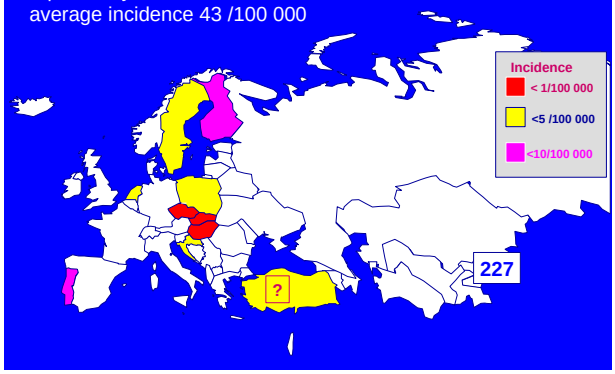


Reported cases of measles in 1996 and 1997



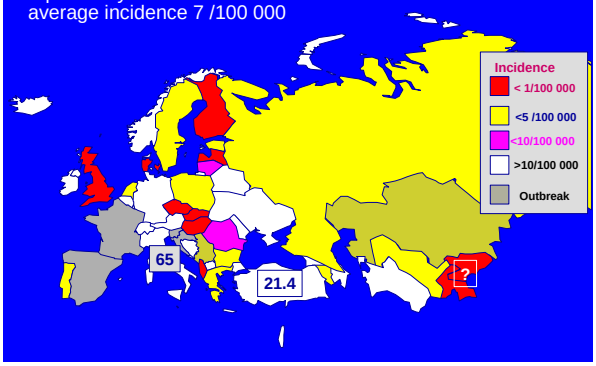
Measles cases per 100 000 in 1987

reported by 22 countries
average incidence 43 /100 000



Measles cases per 100 000 in 1995

reported by 27 countries
average incidence 7 /100 000



Monitoring measles complications

	Encephalitis	SSPE
Notifiable	12	8
Lab. rep.	1	2
Not avail.	3	5
Country	15	15

Measles hospitalization

- proportion of measles cases hospitalized varies enormously.
- average days of hospitalization: 7.6 days ranging from 5 to 10 days.

Response based on answers from 12 countries

Perception of measles as a disease of public health importance

- of the 29 responding countries, 24 (83%) considered measles as a disease of public health importance.
- 10/23 (44%) of the responding countries have estimated the cost of measles disease.

Measles elimination strategies

- all responding countries claim to have a national policy for measles elimination.
- some of them (11) with a target date before 1996
- 6 with target date post 1996

Measles elimination immunization strategies

- Increase coverage: 11 countries.
- Second dose: 5 countries.
- 2nd dose + mass campaign: 2 countries.
- 2nd dose + catch-up: 2 countries.

It is why a:

Strategic plan for measles elimination has been developed

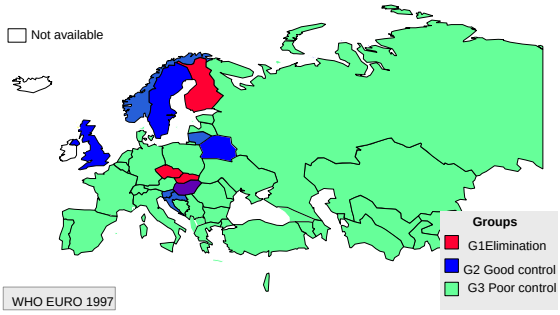
Strengthen surveillance

- monitor vaccine coverage
- reporting of suspected cases
- use of case definition
- establish laboratory resources
- regular feedback

Categorization of countries

- Group 1: Close to elimination
- Group 2 : Good control but potential for outbreaks
- Group 3 : Poor control

Categorization of countries according to their measles achievements in 1996-1997



Recommendation

- The elimination strategy, based on identification of susceptibility, is the most appropriate approach for the European Region
- The EAG endorsed the strategic plan of measles elimination and agreed that the elimination target should bet set at 2007, but could be accelerated in some countries

Acknowledgement

- to all the 44 countries which have answered the questionnaire

ANNEX 2

Measles elimination in Europe: rationale for age-specific susceptibility targets

Measles elimination can only be achieved by maintaining a low level of susceptibility throughout the population This annex explains the rationale for the target levels of susceptibility recommended for measles elimination in Europe.

Target

In the following age groups, the proportion susceptible shall not be greater than:

1–4 years	15%
5–9 years	10%
10–14 years	5%
15+ years	5% in each cohort

Theoretical considerations

Measles is a highly transmissible infection. Most estimates of the basic reproduction number, R_o (the number of secondary cases produced by a typical infective in a totally susceptible population) for measles in developed countries are between 10 and 20 [1]. Basic epidemiological theory states that elimination of disease will be achieved if the proportion susceptible is maintained below the critical value $1/R_0$. This suggests that the threshold for measles in developed countries is approximately 5–10% susceptibility in each cohort. However, this blanket estimate can be refined by using age structured models to set different susceptibility targets for different age groups [2]. Higher levels of susceptibility can be allowed in age groups in which transmission rates are low, particularly if offset by lower levels of susceptibility in other age groups.

Using age structured models, any susceptibility profile can be summarised by the effective reproduction number, R (the number of secondary cases produced by a typical infective at the given levels of susceptibility)[3]. There is a threshold at $R=1$, about which R oscillates during an epidemic cycle. At high levels of susceptibility $R>1$, so each case produces more than one secondary case and the number of cases increases. At low levels of susceptibility $R<1$, so each case produces less than one secondary case, and the number of cases decreases. To achieve elimination low levels of susceptibility must be maintained so that $R<1$. This will also prevent endemic infection from becoming re-established following the introduction of imported cases, although isolated outbreaks cannot be prevented entirely. The smaller value of R, the smaller the chance of an imported infection producing an outbreak.

Applicability of the model

The age specific transmission rates used in the model are derived from age stratified notifications of measles in England and Wales before vaccination was introduced [4]. Similar estimates can be derived from pre-vaccination serological data from Denmark [5]. These parameters have been validated against post vaccination surveillance data from England and Wales[3] and Canada[6]. The model is expected to be broadly applicable to countries with fairly stable population throughout Europe. However, this model is not directly applicable to countries with rapidly growing populations. Further work may lead to a revision of the targets for such countries.

Practical considerations

It is important to ensure that any susceptibility targets are sufficiently low to reach elimination. Thus the target level should be set some way below the threshold at *R=1* to allow a safety margin. This will accommodate some degree of heterogeneity, e.g. small variations in vaccination coverage. However, targets must also be achievable in practice, ideally within existing vaccination schedules. The target level of susceptibility should decrease with age, as waning is not considered a problem and opportunities to give doses of vaccines accumulate through childhood.

Results

At the target levels of susceptibility (figure 1), the value of the effective reproduction number is *R=0.70,* well below the threshold at *R=1* and therefore sufficient to achieve elimination. The targets could be achieved by prolonged high coverage of a routine two dose vaccination programme, or more quickly by a mass "catch up" campaign. They thus represent a balance between practicality and security.

In many European countries, the first dose of measles vaccine is given above the age of 12 months, so that more than 15% of 1 year olds are susceptible. The value of *R* is not increased greatly if the proportion susceptible is not reduced to 15% until the age of 18 months *(R=O. 74)* or even 24 months *(R=0.78).* These results were not sensitive to an increase in the transmission rate in preschool children to the putative French value *(R=0. 75* and *R=0. 80* respectively). However, timely vaccination may assume greater importance in countries with rapidly growing populations.

The safety margin would similarly allow an increase of 5% in the proportion susceptible in any one age group before the threshold at *R=1* was exceeded.

The targets recommended are not the only possible choice. For example, reducing the target level of susceptibility in older age groups would allow some scope for increasing the target in the 1–4 year group. The PAHO elimination strategy sets the maximum level of susceptibility in 1–4 year old children at 25%[7]. No specific targets are set for older age groups; the implicit assumption seems to be that there are no susceptibles in these cohorts following "catch up" and "follow up" campaigns. For a similar vaccination strategy in a European country, the model suggests that a level of susceptibility well above 25% could be tolerated in 1–4 year olds (provided that susceptibility was less than 5% in each cohort aged 5 years or more). This would allow countries to conduct a "follow up" campaign in 1–4 year old children every 4 years.

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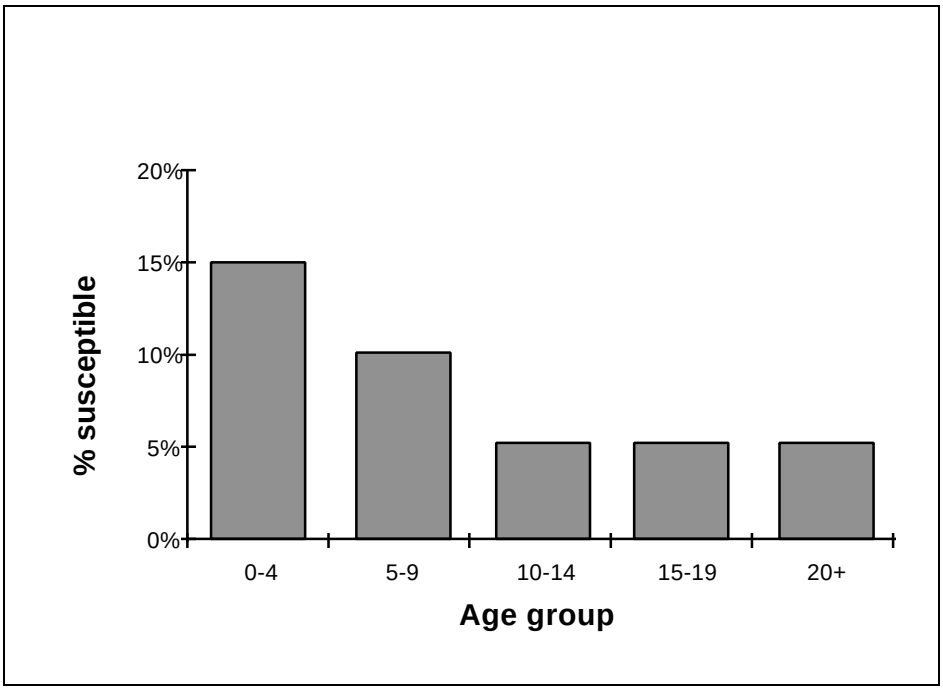
Fig. 1. Susceptibility targets for measles elimination



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7 March 1997

ANNEX 3

Criteria for categorizing measles control

Group 1: Countries close to elimination

Countries in this category will have:

National reporting of suspected measles.

Laboratory confirmation being performed for a high proportion of sporadic cases (at least 1 suspected case per 100 000 population must be tested per year).

Less than 10% of suspected cases will have been confirmed for the last five years.

AND

≥95% coverage dose 1 by age 2 years (for 5 consecutive years or more) and no geopolitical units within the country have a vaccine coverage of <90%

AND EITHER

≥95% coverage of 2 doses (for at least 10 cohorts of children) (with dose 1 given above the age of 12 months)

OR

Age-specific susceptibility is known to be:
1–4 years ≤15%, 5–9 years ≤10%, 10–14 years ≤5%

Group 2: Countries with good control but potential for future outbreaks

Countries in this category will have:

National reporting of suspected measles
Laboratory resources available for confirmation of sporadic cases
Some laboratory testing of suspected cases
Less than 50% of suspected cases which are tested can be confirmed

AND

Coverage dose 1 ≥90% by age 2 years for five consecutive years (given at or above the age of 12 months)

AND

A stable incidence rate[*] of reported measles over five consecutive years or an inter-epidemic period[†] of ≥5 years.

Group 3: Countries with poor control

Countries in this category will have:

Low (< 90%) or unknown coverage for the first dose of measles vaccine

OR

No national reporting of suspected measles.

OR

An inter-epidemic period[‡] of less than 5 years.

[*] The highest annual incidence is less than four fold higher than the lowest rate.
[†] The period between the two most recent years of peak incidence.
[‡] The period between the two most recent years of peak incidence.

Justification for these criteria

Despite the recognition of the importance of national reporting of measles, the accuracy of routine reporting needs to be evaluated. At low levels of coverage and with poor measles control, the incidence of reported measles will depend upon the degree of underreporting. Therefore, the use of an incidence rate of reported measles as a criterion or a target is not recommended. Without any correction for underreporting, such rates are not sufficiently accurate to formulate a country's strategy for elimination. In the absence of information on underreporting in each country, therefore, a criterion based on trends in reported incidence over time will more accurately define the current level of measles control. Countries with good control would expect to have extended the inter-epidemic period to five years or more. In countries with poor control, the inter-epidemic period will be shorter, and they will have experienced an epidemic within the past five years.

With high coverage and better control, the specificity of the clinical diagnosis of measles will be too low to allow accurate monitoring of the programme based on reported cases. Laboratory confirmation in a high proportion of cases is required but a criterion based upon the incidence of laboratory confirmed measles will be prone to differences in the number of cases where laboratory testing is performed. The proportion of cases investigated which are confirmed by laboratory testing will provide an index of the sensitivity of the surveillance based on confirmed cases. To be confident of excluding measles transmission within a country, however, laboratory testing must be performed at an acceptable minimal rate based on the underlying rate of non-measles rash and fever illness.

The precise incidence of non-measles rash and fever illness has not been established and the proportion of such cases which conform to a clinical case definition for measles is unclear. In the United Kingdom during a period of good measles control, a rate of doctor-diagnosed suspected measles of 20 per 100 000 population per year was observed. Sixty-four percent of these cases conformed to the WHO case definition and only 5.3% of these cases could be confirmed as measles by laboratory testing. As rates may vary between countries and over time more experience is required before a final rate is set.

Countries in group two should therefore have some laboratory testing of sporadic cases being carried out, and would be expected to confirm less than 50% of suspected cases. For countries in group one to demonstrate that surveillance of confirmed cases is sufficiently sensitive will require that at least 1 suspected case per 100 000 population is being tested and that fewer than 10% of such cases should be confirmed. This rate will be refined as more countries near elimination and are able to monitor the rate of laboratory testing.

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