Comparison of cost-effectiveness of preventive and reactive mass immunization campaigns against meningococcal meningitis in West Africa: a theoretical modeling analysis
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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
Two strategies for the prevention of epidemic meningitis, based on vaccination with meningococcal A+C polysaccharide vaccine, were examined. The two strategies were:

an emergency (reactive) strategy of vaccination of persons aged 1 to 30 years, implemented when epidemic thresholds (based on epidemiological surveillance data) are reached, as suggested by the World Health Organisation (WHO); and

a preventive strategy consisting of the vaccination of persons aged 1 to 25 years, based on a mass preventive campaign against epidemic meningitis.

Type of intervention
Primary prevention.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised the general population of Senegal inhabitants aged 1 to 30 years.

Setting
The setting was the community. The economic study was carried out in the district of Matam in Senegal.

Dates to which data relate
The effectiveness and resource use data were derived from studies published between 1979 and 1997. The price year was 1997.

Source of effectiveness data
The effectiveness data were derived from a review of published studies and local reports, which was augmented by the authors' assumptions when data were unavailable.

Modelling
A decision tree model was used to simulate epidemic meningitis, and to assess the costs and outcomes of the two vaccination strategies over a time horizon of five years. The model comprised three health states. These were meningitis (both epidemic and endemic), sequelae, and death related to meningitis.
Outcomes assessed in the review
The input parameters for the 3 age groups (less than 1, 1 to 25, and greater than 25 years) and all combined were:

the meningococcal meningitis attack rates among unvaccinated population, per 100,000 inhabitants;

the epidemic case fatality rates;

the annual endemic incidence per 100,000;

the endemic meningococcal meningitis case fatality rates;

the proportion of meningococcal cases with neurological sequelae;

the annual non-meningococcal bacterial meningitis incidence; and

vaccine coverage of preventive and reactive campaigns.

The overall attack rate and unvaccinated attack rate were determined using the epidemic attack rates, epidemic case fatality rates, overall vaccination coverage, and overall vaccine efficacy in the year following immunisation.

Study designs and other criteria for inclusion in the review
The authors stated that one of the primary studies reported data from an actual preventive immunisation campaign against meningococcal A+C meningitis and yellow fever conducted in 1997 in the district of Matam in North-eastern Senegal. Details of the remaining studies were not reported.

Sources searched to identify primary studies
Not stated.

Criteria used to ensure the validity of primary studies
Not stated.

Methods used to judge relevance and validity, and for extracting data
Not stated.

Number of primary studies included
The effectiveness evidence were derived from ten primary studies.

Methods of combining primary studies
The primary studies were combined using narrative methods.

Investigation of differences between primary studies
Not carried out.

Results of the review
For each of the following parameters, the point estimates are presented as base-case (worst-case, best-case).

The total meningococcal meningitis attack rate among unvaccinated population was 616 (258, 1,863) per 100,000 inhabitants.
The epidemic case fatality rates were 25.4% (21.5, 32.6) in the less than 1-year age group, 13.9% (9.1, 16.5) in the 1 to 25-years age group, and 15.6% (10.6, 25) in people aged greater than 25 years.

The total annual endemic incidence per 100,000 inhabitants was 25.8 (base-case, 94).

The total endemic meningococcal meningitis case fatality rate was 11.6% (base-case, base-case).

The proportion of meningococcal cases with neurological sequelae was 21.7% (base-case, base-case) in the less than 1-year age group, 18.5% (base-case, base-case) in the 1 to 25-years age group, and 35.7% (base-case, base-case) in people aged greater than 25 years.

The annual non-meningococcal bacterial meningitis incidence was 44.7 (base-case, base-case) per 100,000 inhabitants.

The proportion of meningococcal cases with neurological sequelae was 21.7% (base-case, base-case) in the less than 1-year age group, 18.5% (base-case, base-case) in the 1 to 25-years age group, and 35.7% (base-case, base-case) in people aged greater than 25 years.

The overall vaccination coverage ranged from 73.8 to 79.2%.

The overall vaccine efficacy in the year following immunisation ranged from 85 to 90%.

The calculated attack rates among the unvaccinated population, per 100,000 population, ranged from 221 to 1,360 in the less than 1-year age group, from 480 to 1,837 in the 1 to 25-years age group, and from 53 to 449 in people aged greater than 25 years.

Methods used to derive estimates of effectiveness

The overall attack rate and the unvaccinated population attack rate were calculated using the equations of Pinner et al. (see Other Publications of Related Interest).

Estimates of effectiveness and key assumptions

The authors assumed the following:

- vaccine coverage was the same in all targeted age groups and was equal to the overall coverage;
- the reactive campaign would start after a certain level of cumulative weekly incidence (60 cases per 100,000 inhabitants);
- the interval between the preventive campaign and the epidemic onset was 12 to 23 months; and
- the polysaccharide A+C vaccine has no influence on Neisseria meningitidis carriage, and thus no influence on herd immunity.

Measure of benefits used in the economic analysis

The benefit measures used in the economic analysis were the numbers of cases, deaths or sequelae prevented by each strategy and by the preventable fraction (the number of outcomes prevented divided by the number of outcomes that would have occurred without vaccination). The benefit measures were derived using modelling and a 3% discount rate (worst-case 5%, best-case 1%) was used.
Direct costs
A 3% (5, 1) discount rate was applied since the costs were incurred over more than two years. The unit costs were reported separately from the quantities of resources. The health services costs included in the economic analysis were for vaccination (vaccines, injection material, logistics and staff), meningitis surveillance (in the reactive programme), meningococcal meningitis case investigation, and care for acute meningococcal meningitis cases. Due to the lack of data, the transportation costs from the central to the peripheral level of care and administrative expenses were not included in the analysis. The cost/resource boundary adopted in the study was that of the Epidemic Disease Control Program in Senegal. The costs and quantities were estimated from published studies. The total costs of the two strategies were calculated using modelling. The price year was 1997.

Statistical analysis of costs
The costs were treated deterministically.

Indirect Costs
The indirect costs were not included in the analysis.

Currency
Francophone Africa currency (CFA francs). This was converted into US dollars ($) using the 1997 average exchange rate.

Sensitivity analysis
Best- and worst-case scenarios were simulated using the values reported in the 'Results of the Review' section. Univariate sensitivity analyses were also conducted to assess the robustness of the estimated cost-effectiveness ratios to variations in several parameters. The parameters investigated were the epidemic attack rate among the unvaccinated population, the annual endemic incidence, the reactive and preventive strategy vaccination coverage rates, the interval between a preventive mass campaign and when an epidemic would otherwise have occurred, the cumulative epidemic incidence reached before the beginning of reactive vaccination, the costs of preventive or reactive vaccination, and the costs of treatment in epidemic and endemic situations.

Estimated benefits used in the economic analysis
In a population of 100,000 people, the total cases of meningitis prevented were 333 with the reactive strategy and 408 with the preventive strategy;

the total deaths prevented were 45 (reactive) and 55 (preventive), respectively; and

the total sequelae prevented were 54 (reactive) and 66 (preventive).

Thus, the preventive strategy led to better results than the reactive strategy in all benefit measures.

The preventable fraction for meningitis cases was 59% for preventive vaccination and 49% for reactive vaccination.

The preventable fraction for deaths was 57% for preventive vaccination and 47% for reactive vaccination.

The preventable fraction for sequelae was 49% for preventive vaccination and 40% for reactive vaccination.

Cost results
In a population of 100,000 people, the total costs were $44,248 with reactive vaccination and $24,259 with preventive vaccination.
Synthesis of costs and benefits
An incremental cost-effectiveness analysis was performed to combine the difference in the total costs and the difference in each of the benefit measures obtained with the two strategies.

The costs per case prevented were $133.07 with reactive vaccination and $59.52 with preventive vaccination. The corresponding costs per case for death prevented were $973.36 (reactive) and $437.29 (preventive), respectively, and for sequelae prevented, $817.12 (reactive) and $366.79 (preventive).

For the base-case, the incremental costs with reactive vaccination over preventive vaccination were -$266.42 per case prevented, -$1,995.63 per death prevented, and -$1,667.70 per sequelae prevented.

The preventive strategy dominated reactive vaccination, which led to higher costs and fewer cases, deaths and sequelae prevented.

In the best-case scenario, compared with reactive vaccination, the preventive strategy resulted in cost-savings of $29,902 and 416 incremental cases prevented, 64 incremental deaths prevented, and 63 incremental sequelae prevented in comparison with reactive vaccination. It also resulted in higher preventable fractions for cases, deaths and sequelae. The preventive strategy still dominated.

Under worst-case assumptions, the analysis showed that the reactive strategy was preferred so long as one was willing to spend at least $143.52 per extra case prevented, $1,796.58 per extra death prevented, and $697.24 per extra sequelae prevented.

The univariate threshold sensitivity analyses showed the conditions under which preventive vaccination was cost-effective in comparison with the reactive strategy. Such conditions were when the preventive vaccination coverage was higher than 71%, the interval between the preventive campaign and when the epidemic would otherwise have occurred was less than 36 months, and the reactive campaign vaccination coverage was less than 94%.

Authors’ conclusions
Mass preventive vaccination against meningitis was cost-effective, as it reduced costs and prevented more epidemic and endemic cases, deaths and sequelae than a reactive strategy within the 5-year analytical horizon adopted in the study.

CRD COMMENTARY - Selection of comparators
The rationale for the choice of the comparators was clear. Reactive and preventive vaccination strategies were compared, as both represented actual implemented options for managing the general population at risk of meningitis in developing countries. In particular, reactive vaccination was the option recommended by the WHO. You should decide whether they represent valid comparators in your own setting.

Validity of estimate of measure of effectiveness
The analysis of the effectiveness used a review of published studies. The search methods were not reported and narrative methods were used to combine the estimates from the primary studies. It was not stated whether the authors took into account differences across the primary studies when estimating the effectiveness, but the authors stated that "the most likely value of each variable" was selected. The authors also made some assumptions in order to derive data for the decision model, due to the lack of published data available. Sensitivity analyses investigated the uncertainty surrounding the effectiveness estimates used in the model.

The ability to accurately predict a meningitis epidemic was the biggest unknown. If no epidemic occurred within the 5 years following a preventive mass immunisation campaign, mass prevention would only have prevented endemic cases at a cost of $364.56 per case prevented.

Validity of estimate of measure of benefit
The benefit measures used in the economic analysis were obtained from the decision model. The discounting was
appropriate, as the time horizon of the analysis was five years.

**Validity of estimate of costs**
The perspective adopted in the study was explicitly reported, and it appears that all the relevant categories of costs have been included in the analysis. Some cost categories were not included because such data were not found in the literature. However, their impact should not have changed the conclusions of the analysis. Both the unit costs and price year were reported, thus enhancing the reproducibility of the economic analysis in other settings. The cost estimates were somewhat specific to the study setting and were treated deterministically in the base-case, although several sensitivity analyses were conducted.

**Other issues**
The authors did not compare their findings with those from other studies. In terms of the generalisability of the study results to other settings, the authors stated that the cost estimates used in the decision model were derived from a single small location, which may not have been representative of other areas in Africa. The analysis referred to the general population and this was reflected in the conclusions of the study. The authors commented on some limitations of their analysis. For example, the fact that epidemics may have a significant impact on outcomes such as tourism and political stability, and the fact that the indirect costs were not estimated as a societal perspective was not adopted.

**Implications of the study**
The authors suggested that, in sub-Saharan Africa, mass preventive vaccination may represent a cheaper and more effective approach than reactive vaccination in developing countries without effective surveillance systems. Future studies should focus on assessing the duration of vaccine efficacy in younger age classes.

**Source of funding**
None stated.

**Bibliographic details**

**PubMedID**
11348706

**Other publications of related interest**

**Indexing Status**
Subject indexing assigned by NLM

**MeSH**
Adolescent; Adult; Child; Child, Preschool; Cost-Benefit Analysis; Decision Trees; Disease Outbreaks /economics /prevention & control; Humans; Immunization /economics; Infant; Meningitis, Meningococcal /economics /epidemiology /immunology /prevention & control; Meningococcal Vaccines /economics /pharmacology /therapeutic use; Models, Theoretical; Senegal /epidemiology; Sensitivity and Specificity

**AccessionNumber**
22001006704