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Application of an Economic Model to the Study of Leprosy Control Costs [1]

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Leprosy is only one among many health problems which requires attention. In a number of countries leprosy competes with other diseases for a part of a limited health budget. Cost factors will therefore be determinant in deciding the priority to be assigned to leprosy, the feasibility or opportunity for leprosy control, and the strategy which will use resources in the most efficient and effective way in order to decrease the size of the leprosy problem.

There are several methods which on theoretical grounds could be considered to control leprosy. One is the widely used mass outpatient treatment, based on early detection and regular treatment of the highest possible proportion of infective patients, as recommended at various WHO meetings and leprosy congresses ([5]). It centers around two widely accepted premises: 1) man is the sole reservoir for the causative agent *Mycobacterium leprae;* and 2) sulfone drugs administered to infective patients eventually render them noninfectious. This has been the basis of leprosy control schemes carried out over the last three decades. It has apparently reduced the incidence, that is the number of new cases occurring per year in the exposed population, in several countries. Where results have not been so encouraging, this has at times been attributed to insufficient efforts in detecting patients at early stages and/or to poor attendance for treatment, and these defects, in turn, to an insufficient budget.

Other control methods do exist. Isolation of patients was widely used in the past when no active drugs were available; recently it has been advocated again in spite of its manifest psychological drawbacks and the obvious problems of implementation. The recent emergence of sulfone-resistant strains of *M. leprae* will soon oblige us to reconsider the strategy of leprosy control ([4]). This will have major cost implications in the allocation of personnel, building of facilities, laboratory use and choice of drugs. Under these conditions, decisions also have to be made for the allocation of funds for research. It may be that investing in research is the most rational choice in the long run. It is therefore important to know how potential methods, should they be developed, could affect the cost of leprosy control in the years to come. Among new methods still to be made available, important efforts are currently carried out with the view of making immunization possible. Although no vaccine against leprosy has been developed yet, this is a promising area of research.

The relative effectiveness of current or potential control methods can be tested using a computer simulation model. The cost of these control methods varies widely. The aim of this study is to calculate the cost of each control methods at various levels of population coverage. Cost can then be compared with effectiveness as determined by an epidemiometric model previously developed. It is expected that this analysis will help to decide the optimal strategy for leprosy control.

METHODS

The model used for simulating the epidemiologic trends under various control conditions has been described elsewhere ([2,3]). The following seven control methods were considered.

I. The current method used for leprosy control in many countries which is based on the earliest possible detection of new cases after the onset of the disease and regular treatment of all active cases (activity is defined according to clinical and bacteriologic criteria). In this study, the term "reference

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control method" is used to refer to this control method commonly applied in the study area of Polambakkam, South India. The specific operational features and epidemiologic indices have been described previously ([2,3]).

II. Vaccination with a BCG-type vaccine. While this provides no protection against the disease, the vaccine is assumed to induce the tuberculoid type in those infected. (The term BCG-like has been used throughout this study for sake of convenience. It does not imply that BCG actually has this effect.)

III. Vaccination with a leprosy-specific vaccine which confers a 100% protection against all types of the disease (incomplete coverage of X percent of the population with a 100% effective vaccine being taken as giving similar effect on transmission as 100% coverage of the population with a vaccine conferring X percent protection).

IV. The current method referred to in (I), modified with regard to the rate of attendance for treatment. The annual rate of patients resuming treatment is increased in order to simulate higher attendance.

V. The current method referred to in (I), modified with regard to the delay between the onset of the disease and detection. This delay is modified in order to simulate earlier detection.

VI. Isolation of lepromatous and other bacteriologically positive patients for one year immediately following detection.

VII. Isolation of lepromatous and other bacteriologically positive patients for one year immediately following detection and continued isolation of half these patients during subsequent years until death or cure.

These control methods will be referred to subsequently as methods (I) to (VII).

The effectiveness of each method taken individually was simulated over a 20 year period, at 10 to 100 percent levels of coverage. Annual incidence was taken as an indicator of control effectiveness ([1]). The epidemiologic data used in the model were collected in the Polambakkam leprosy control scheme in South India ([3]). In order to calculate the annual cost per patient, the control methods were analyzed into their basic task components. These are listed in Table 1.

Control methods II and III are characterized by vaccination of the whole population in year one followed by vaccination of all newborn babies during subsequent years. Control method IV requires specific measures diverting the time of the personnel such as house visits and health education aimed at convincing patients having abandoned treatment to resume it. Control method V aims at shortening the delay between the onset of the disease and its detection. In the model, the time interval between onset of disease and detection followed a negative exponential with 75% of new patients detected within the year following the onset of the disease. Under local conditions, it was considered that earlier detection with shortening of the average delay before detection could best be achieved through an increase in health education, better individual care of identified patients, advertising of the campaign against leprosy, and possibly the investigation of contacts. This could be carried out as part of the normal procedures conducted by field workers, at the cost of reducing productivity in their routine screening activities. Control methods VI and VII require an institutional network for the isolation of patients, hospital care, and a system for selecting and referring bacteriologically positive cases requiring isolation.

The unit cost of each task per patient is defined as the hourly salary of the personnel assigned to the task divided by the number of patients for which the task is carried out in an hour. When a task implies the successive intervention of two or more personnel, the cost of the various subtasks is calculated separately and then added together. The cost of each task per patient year is reached by multiplying the unit cost by the number of times the task is performed in one year. Cost parameters were estimated on the basis of observations made in a number of leprosy control schemes in Southeast Asia. In order to avoid expressing the cost in a given currency, which would vary from country to country and over time, all costs have been expressed in terms of an index based on the cost of one weekly session of drug delivery to a patient including bimonthly examinations for follow-up.

These cost estimates need some further explanation:

1. The hourly salary of field workers and supervisors is calculated on the basis of wages paid.

2. The work load per hour for each task is the average calculated from direct observations in outpatient clinics.

TABLE 1. *Allocation and cost of basic tasks in each control method.*

Ref. no. of task i	Basic task	Tasks involved in strategies nos. I	II	III	IV	V	VI	VII	Cost equation	Cost figure (in basic cost unit)
1	initial examination of a suspected case and recording	+	+	+	+	+	+	+	$\frac{C_A}{H_{A1}} + \frac{C_B}{H_{B1}}$	5.0
2	periodic follow-up of an active case for possible discharge	+	+	+	+	+	+	+	$\frac{C_B}{H_{B2}}$	3.5
3	drug delivery and supervision of treatment (control of reactions and complications)	+	+	+	+	+	+	+	$\frac{C_{A+D}}{H_{A3}}$	1.0
4	periodic follow-up of an inactive case for detection of reactivation and relapse	+	+	+	+	+	+	+	$\frac{C_B}{H_{B4}}$	3.5
5	treatment and follow-up of secondary diseases and leprosy complications, including care of ulcers and physiotherapy, average per patient	+	+	+	+	+	+	+	G	201.3
6	bacteriological examination for patient classification and follow-up of positive cases	+	+	+	+	+	+	+	E	4.0
7	specific activities directed at improving regular attendance at treatment sessions				+				$\frac{C_A}{gHA1}$	variable
8	specific activities directed at shortening delay in detection					+			$\frac{C_A}{kH_{A1}} + \frac{C_B}{H_{B1}}$	variable
9	vaccination per person (year 1 only)		+	+					V	1.0
10	vaccination of newborn babies								U	0.8
11	institutional care (isolation)						+	+	Q	71.2
S	transportation cost for mobile treatment								S	300,000.00
Z	administrative costs								Z	631,800.00

C = hourly salary. A = field worker. B = supervisor.
H_{Ai} or H_{Bi} = average number of patients seen by worker of type A or B performing task i.
D = cost of one treatment dose.
G = average cost of care for complications or secondary diseases per consultation.
E = cost of one bacteriological examination, including collection of specimens, transport, laboratory processing, use of microscope and salary of laboratory technician.
g = reduction coefficient for time spent by worker to strengthen attendance to treatment.
k = reduction coefficient for time spent by worker in activities leading to earlier detection.
V = cost of vaccinating one person in mass vaccination scheme.
U = cost of vaccinating one baby through the general health services.
Q = daily cost of hospitalization in leprosarium. S = transport cost. Z = administrative cost.

3. The allocation of tasks to different types of personnel was according to the job distribution in typical leprosy control schemes in Southeast Asia. A field worker is a worker who has received a short training, and who is capable of carrying out preliminary screening of suspects, keeping records, delivering treatment, and searching out patients who have stopped attending for treatment. A supervisor is a paramedical worker with more elaborate training enabling him to confirm diagnosis, carry out clinical examinations for discharge, follow up inactive cases and detect relapses, treat intercurrent diseases, and deliver special leprosy care including physiotherapy and treatment of ulcers.

4. Periodicity and repetition of procedures such as examination and treatment were set according to current practice in the reference area. Bacteriologic examination under model conditions is performed once a year in lepromatous (and borderline) cases.

5. The annual costs for specific drugs, and for nonspecific and specialized leprosy care, were calculated directly from pharmacy records; the unit cost for bacteriologic examinations was derived from a separate costing of laboratory activities.

6. The cost of field vaccination including vaccine and operational procedures, in case it becomes available, was extrapolated from former BCG vaccination campaigns carried out in South India.

7. The cost of vaccinating one newborn baby through the general health services was put arbitrarily at 80% of the cost for one individual in a mass vaccination campaign.

8. Early detection, the specific task required for control method V, has not been singled out, since it cannot be analyzed in terms of patients seen per hour. Instead, it was assumed that the field worker would dedicate part of his screening activities to health education in order to achieve earlier detection. However, this would mean either a decrease in the number of patients screened per hour, or conversely an increase in the number of field workers.

9. Isolation costs were calculated using current estimates for the hospital care of leprosy patients in the study area, excluding depreciation and assuming that use is made of existing institutional facilities and no new facilities are built.

10. Transport costs were estimated from available budgetary data and considered as constant. Obviously this should be modified in future estimates owing to the escalating cost of petrol. Transport costs were taken as similar for control methods I to V, which is consistent with local operational methods.

11. Estimates of administrative costs were based on the published budgets available for various leprosy control schemes. They include doctors' salaries, the cost of time spent in nonproductive tasks and the cost of inefficient procedures. These estimates should be considered as educated guesses.

RESULTS

A strategy is defined as a specified control method applied at a given level of coverage, this coverage being the number of individuals to whom the method is applied, expressed as a percentage of those to whom it is applicable. The annual cost of a strategy is calculated by multiplying the cost of the various tasks by the number of individuals to whom these tasks are applied during the year, as predicted by the model (Table 1). Equations for the annual cost of strategies relating to control methods I to VII are given in Table 2.

The various strategies have been compared using the following cost and effectiveness parameters:

a) annual costs over 20 successive years.

b) cumulative costs since initiation of strategy, up to 20 years.

c) annual incidence, i.e., the number of cases (new and relapses) put under treatment per year, over 20 successive years.

d) annual prevalence, i.e., the number of cases under treatment, per year, over 20 successive years.

e) cumulative prevalence, i.e., the total number of person-years of treatment since initiation of simulation, up to 20 years.

Model predictions have shown that the current method is quite effective in reducing incidence ([3]). Annual incidence falls from 27.1 at time 0 to 22.7 per 10,000 after 5 years and 10.3 per 10,000 (or a 60% reduction) after 20 years (Table 3). In order to measure the relative effectiveness of the various strategies it then becomes necessary to compare the incidences over the years as predicted by the model with the incidence which could be expected if only the current control method was used. Hence, the incidence resulting

from each control method (as predicted by the model) has been related to incidence expected to result from the current method, this being expressed as a ratio of incidences.

The gain in effectiveness at year j has been computed as:

$$\Delta e_j = \left(1 - \frac{\text{predicted incidence}_j\text{, with simulated method}}{\text{predicted incidence}_j\text{, with current method}}\right) \times 100$$

TABLE 2. *Annual cost of each control method.*

Control method	Cost per year
I—current method	$N_1\left(\frac{C_A}{H_{A1}}+\frac{C_B}{H_{B1}}\right)+N_2\left(\frac{C_B}{H_{B2}}\right)+N_3\left[6\left(\frac{C_A}{H_{A3}}\right)+52D\right]+N_4\left(\frac{C_B}{H_{B4}}\right)+(N_5+G)+(N_6\times E)+S+Z$
II—nonspecific vaccination III—specific vaccination	[Equation method I] + (P × V) for year 1 and [Equation method I] + (R × U) for subsequent years
IV—improvement of attendance for treatment	Equation method I + $N_7\left(\frac{C_A}{H_{A7}}\right)$
V—earlier detection	$N_1\left(\frac{C_A}{kH_{A1}}+\frac{C_B}{H_{B1}}\right)$ + . . . as per equation I
VI—isolation of all lepromatous cases for one year after detection	[Equation method I] + N_{10} (365 × Q)
VII—isolation of all lepromatous cases for one year and maintained for half of them in subsequent years	[Equation method I] = $(N_{10}+0.5N_{11})\times(365\times Q)$

N_1 = number of new cases + number of relapses detected in a year.
N_2 = number of patients becoming inactive in a year.
N_3 = number of patients treated in a year.
N_4 = number of inactive patients followed up in a year.
N_5 = number of patients treated for complications or secondary diseases in a year (20% of treated patients).
N_6 = number of lepromatous and borderline cases in a year.
N_7 = number of patients resuming treatment in a year.
N_{10} = number of new lepromatous and other bacteriologically positive cases in a year.
N_{11} = number of lepromatous and other bacteriologically positive cases existing in a year which were detected during previous years.
P = population of the area (with 1% annual increase).
R = number of newborn babies (birth rate 30 per 1,000).

TABLE 3. *Annual incidence per 10,000 population for methods I to VII at horizons of 5, 10, 15, and 20 years (100% coverages).*

Time horizon	Control methods						
	I	II	III	IV	V	VI	VII
0 year	27.10						
5 years	22.72	21.74	15.04	22.81	22.10	21.26	21.17
10 years	16.01	15.05	0.25	15.56	14.88	12.85	12.66
15 years	12.52	10.66	0.00	11.78	11.30	9.10	8.90
20 years	10.28	8.13	0.00	9.43	9.09	6.79	6.61

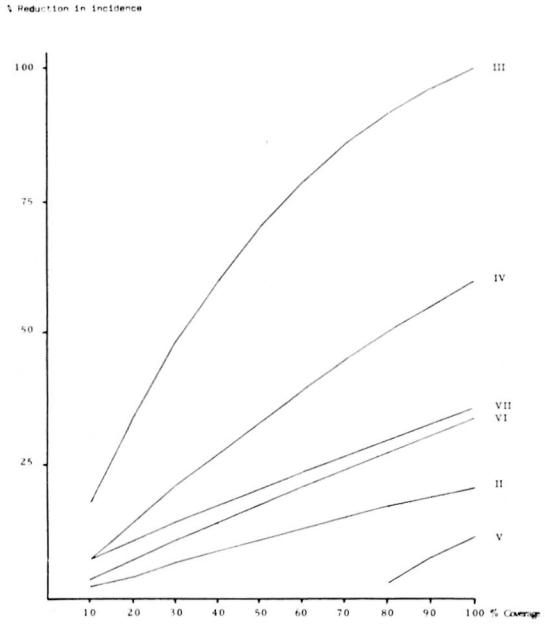

FIG. 1. Gain in effectiveness (ratio of incidences) for methods II to VII, to incidence with the current method I, various levels of coverage at 20 years.

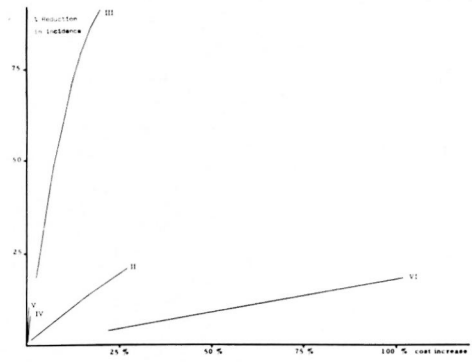

FIG. 2. Gain in effectiveness (ratio of incidences) for methods II to VI, to incidence with current method I, according to cumulative cost increases at 20 years.

At 20 years, the greatest ratio, that is the greatest gain in effectiveness, is achieved by specific vaccination followed by improvement of attendance (method IV), prolonged isolation (VII), one-year isolation (VI), non-specific vaccination (II), and earlier detection (V). Effectiveness increases with coverage for all control methods, what could be expected from model predictions since each of the method has been shown to be more effective than the current method. Whatever the coverage, the ranking is the same, specific vaccination showing the greatest relative reduction in incidence as compared to other methods at similar coverages (Fig. 1).

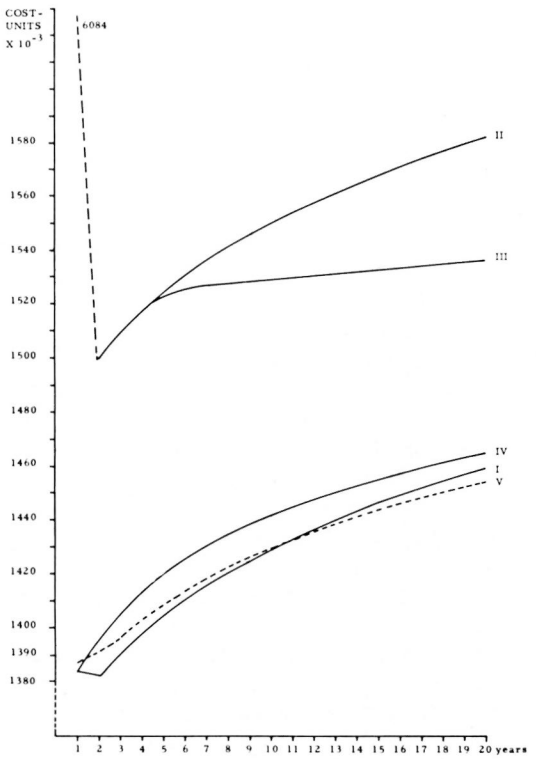

FIG. 3. Cost of control methods I (current), II and III (vaccination), IV (higher attendance to treatment), and V (earlier detection) at 100% coverage, over a 20 year period in 1,000 cost-units. For definition of cost-units see text.

The gain in effectiveness has been studied as it relates to the increased cost of each method over the current method. The cost-effectiveness of each control method was studied using cumulative cost increases over a simulated period of 20 years (Fig. 2). After 20 years, specific vaccination is by far the most cost-benefit method, both when only cost of maintaining protection in newborns is considered or when the cost of vaccinating the whole population during the first year (amounting to 4.4 times the annual first year cost of the campaign with current method) is spread over the 20 year period. One-year isolation runs the last. Both improvement of attendance and earlier detection show a very rapid increase of effectiveness for small increments of costs, the final gain in effective-

ness at high coverage remaining however very low.

For most of the strategies, the annual cost continues to increase over time in spite of a decrease in incidence (Fig. 3). The respective contributions of the different tasks in the annual cost of each method have been analyzed. Results for the current control method over a 20 year period indicate that this increase is mainly due to drug delivery and supervision and care of complications or secondary diseases (Fig. 4). This suggests that prolonged treatment of patients with low discharge or death rates plays an important role in maintaining high costs over the years. It has been shown that with current control method annual prevalences of active cases as well as cumulated prevalences are slowly, albeit steadily, decreasing over the 20 year simulation period. Vaccination, either specific or BCG-like, shows a further reduction in both indicators ([2]).

In the population of the model, lepromatous patients are in principle maintained under treatment for life and nonlepromatous patients receive a consolidation treatment before being declared cured. This has to be taken into consideration for the cost analysis. Prevalence was therefore taken as including all treated patients, either active or inactive.

Reduction in annual prevalences and cumulated prevalences as compared to the reduction expected with the current control method are expressed as ratios of prevalence reductions. These have been calculated in a way similar to the gain in effectiveness used for expressing incidence ratios. When these ratios are plotted against respective cumulative cost increase as compared to current method, the greatest ratio per unit of cumulated cost increase is achieved by specific vaccination. For a 20.7% cumulated cost increase at 20 years, the ratio of annual prevalences, that is the effectiveness of the method in terms of prevalence, is 31.1% (Fig. 5). The ratio in total 20 years cumulated prevalence reaches 28.8% (Fig. 6). With the current method, annual prevalences have been found to increase over the years when all treated patients and not only active cases are taken into consideration. A decrease in prevalence of total treated patients is obtained only with specific vaccination.

In order to clarify the reason for this persisting high prevalence, an analysis was

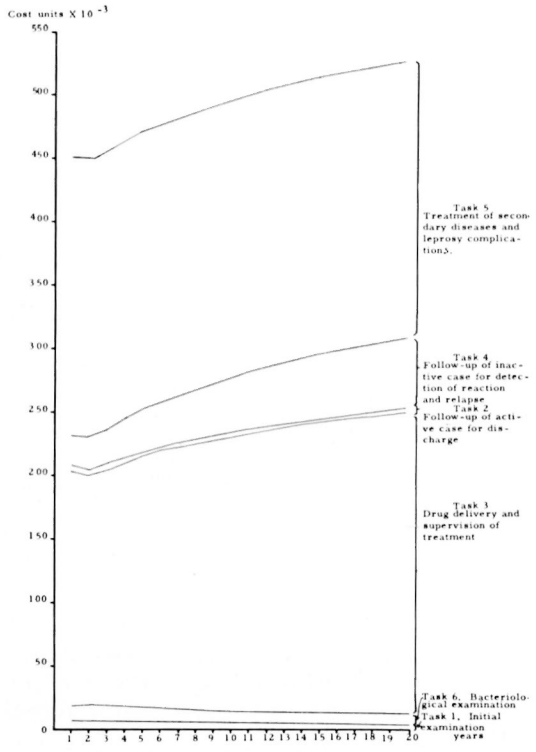

FIG. 4. Respective contributions of each task to the annual cost of the current method, over a 20 year period.

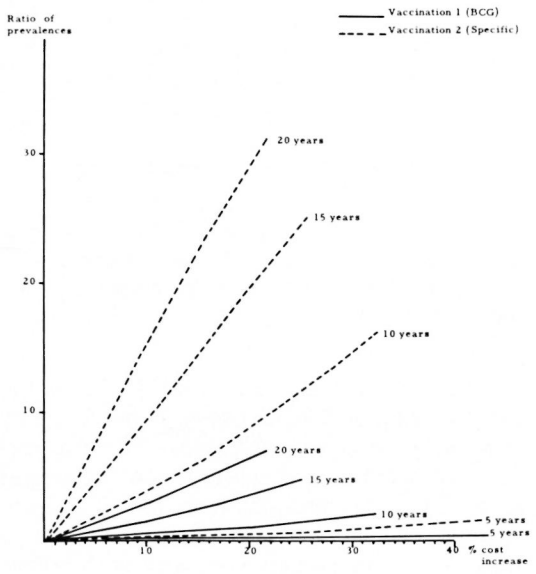

FIG. 5. Annual prevalence ratios for methods II and III (vaccinations), according to cumulative cost increases, at 5, 10, 15, and 20 years.

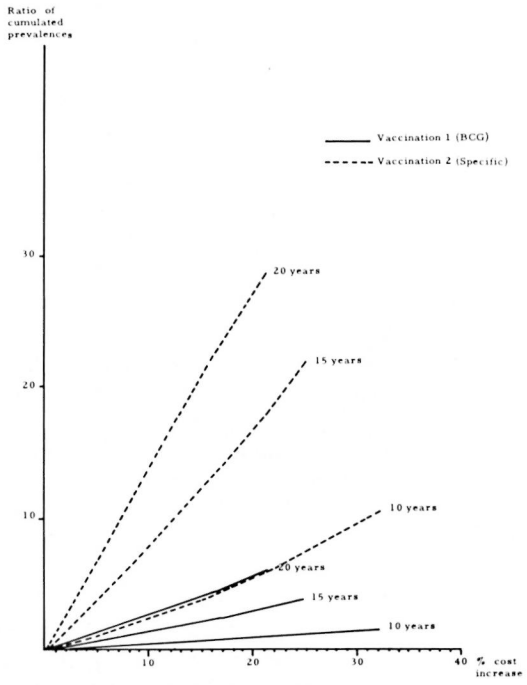

FIG. 6. Cumulated prevalence ratios for methods II and III (vaccinations), according to cumulative cost increases, at 5, 10, 15, and 20 years.

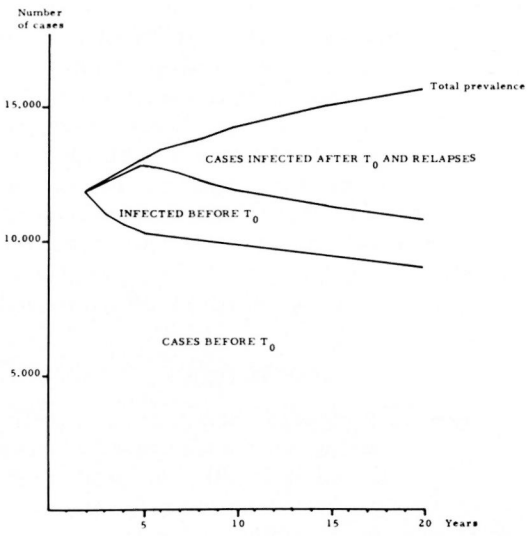

FIG. 7. Annual prevalence of treated cases (active and inactive) over a 20 year period, according to infection and illness status at the time the simulation was initiated (t_0).

carried out on the respective contribution of each category of patients to the prevalence at successive years according to their status at the time the simulations were initiated. Prevalence at any time can be divided into three components: a) the prevalence due to old cases in which the onset of the disease occurred before the time the simulations were initiated (taken as time zero); b) prevalence due to patients who at time zero were already infected but still in the latency stage, and in whom onset of the disease occurred after control methods were initiated; and c) cases infected and consequently detected after time zero (Fig. 7). This analysis carried out on the current method shows that the number of old cases is slowly decreasing, presumably either through death or cure, while there is a significant but temporary increase in patients infected but without apparent disease at the time the simulation was initiated. It should be noted that, according to the assumptions of the model, vaccination has no effect on subjects already infected. These will develop the disease over several years after the vaccination has taken place.

DISCUSSION

Specific vaccination at high coverage is by far the most effective method for reducing incidence in the long term, if one can afford the high initial budget for mass vaccination and the increased cost of maintaining coverage through the vaccination of babies. Specific vaccination is the only method which can reduce incidence to zero, that is, interrupt transmission completely within the 20 year simulation period, if applied at sufficient coverage. From the point of view of cost-effectiveness, if specific vaccination at the cost assumed in the model was to become a reality, it would definitely be the most advantageous method.

In the absence of vaccination, other methods, such as either an increased rate of resuming treatment or earlier detection, can achieve relatively significant results at a minimal cost. BCG-type vaccination is considerably less advantageous. Segregation is both extremely expensive and less effective than other measures.

It could come as a surprise to public health managers concerned with long-term budgeting that, in spite of a marked decrease in incidence, the annual cost of most of the methods discussed increases over time. Only the isolation of lepromatous patients for one year after detection shows a gradual decrease in cost as fewer patients need isolation. With the exception of earlier detection

(method V), all other control methods remain more expensive than the current method over the simulation period of 20 years. Reduction by 100% of the delay between onset of disease and detection, that is immediate detection at onset, becomes less expensive than the current method only after 12 years. The current control method costs remain fairly constant; even so there is a 5% total increase over the 20 year simulation period, although incidence is reduced by 60% after this time.

In order to investigate possible reasons for this seemingly paradoxical observation, the cost of the current method (I) has been analyzed into its various task components. This analysis over a 20 year period shows that a large part of the budget is taken up by a) drug delivery and treatment supervision, and b) care of complications and secondary diseases. A significant though smaller proportion is needed for the follow-up of inactive cases to detect reactivation and relapses, since the number of discharged cases to be examined periodically increases over time. The cost of examining new cases decreases as their number goes down, this representing a negligible part of the total cost. In brief, the major cost item in leprosy control is the prolonged therapy for and supervision of patients. This is a direct consequence of the slow action of the drugs used and the strict criteria adopted for discharge.

Yearly trends show that both with methods currently available and methods still in the developmental stage such as vaccination, it would be wrong to expect a drastic reduction in cost over two decades even though control of the disease is made considerably more effective.

Managers may be interested in prevalence rather than incidence as an indicator of effective leprosy control. Prevalence can be considered a valid parameter in cost-effectiveness analysis when reduction of the annual total number of active patients rather than new patients is the objective of leprosy control. Annual prevalence will reflect the total operational leprosy load in a given year. Cumulative prevalence over a period of years, in this case two decades, will reflect the total amount of money to be allocated to leprosy control for a long period as well as the total amount of person-years of suffering. With both these indicators, specific vaccination is still the most effective control method with the highest cost-benefit ratio.

These results indicate that should a specific vaccine be developed at an acceptable price it would revolutionize the whole future of leprosy control. These observations justify the considerable research effort currently aimed at developing such a vaccine.

On the other hand, fast acting drugs should also be investigated as a possible means of increasing effectiveness. Vaccination has only a delayed effect on the transmission of leprosy. It reduces the number of future cases by preventing their initial infection, but it has no effect on existing cases which are disseminating the disease or on potential cases still in the incubation stage. By contrast, effective fast-acting drugs could dry up the reservoir of infection by curing both existing cases and new cases as they emerge. This calls for more research in the field of leprosy therapeutics.

These results do not intend to be generalized to all leprosy control schemes operating at present. The epidemiologic context and the cost factors vary. The possible generalization of the model to other areas and the assumptions required for this generalization have been discussed elsewhere ([3]). It is assumed that if the epidemiometric model is valid, predictions could hold for other high prevalence areas with similar conditions, that is homogeneous mixing of the population, no clustering of the disease, and few transfers of patients at the boundaries. While it is in no way suggested that the results of the cost-effectiveness analysis could be applied as such to other situations, the introduction of appropriate cost parameters will help in making decisions on a rational basis.

SUMMARY

The effectiveness of various control methods for reducing the incidence of leprosy have been tested over 20 years and compared with predictions made using the present current control method (early diagnosis and mass treatment). Specific vaccination of the whole population, a control measure yet to be developed, has been identified as the most effective strategy in the long run.

A cost-effectiveness analysis has been carried out for three indicators, annual incidence, annual prevalence and cumulative prevalence at 20 years, using cumulative costs. The analysis indicates that specific

vaccination at high levels of coverage is the most effective method for controlling incidence in the long term. Provided the cost of the vaccination campaign during the first years (roughly fourfold the funds required for carrying out the current strategy) can be supported, specific vaccination is also the most cost-effective method where a high level of effectiveness is required. Specific vaccination is still the most advantageous method if prevalence or cumulative prevalence are taken to indicate the effectiveness of leprosy control. The BCG-type of vaccination is not only less effective, it is also less cost-effective.

Reducing the rate of abandonment of treatment (which in the model has been simulated by increasing the rate of resuming treatment) and earlier detection both appear as useful methods under conditions of severe budgetary constraints. Their ultimate effectiveness in terms of incidence reduction is, however, very small. As expected, segregation is costly and ineffective compared with other methods.

In each simulation, the cost of treating the backlog of patients already ill or infected (incubating) at the time the control measures are initiated is high. Methods aimed at reducing transmission, such as vaccination, early treatment or segregation, have long-delayed effects on the cost even if incidence is reduced. The major cost item in these control measures is the prolonged or even life-long treatment of patients.

The development of fast-acting, effective treatment is likely to be the only way to reduce the cost in the short term. Thus, in addition to research aimed at developing a vaccine for leprosy, resources should also be allocated for developing new therapeutics.

RESUMEN

Se probó la efectividad de varios métodos de control para reducir la incidencia de lepra durante un periodo de 20 años y los resultados se compararon con los obtenidos usando los métodos actuales de control (diagnóstico temprano y tratamiento en masa). Se concluyó que la vacunación específica de toda la población, una medida de control aún no aplicada, es la estrategia más efectiva a largo plazo.

El análisis de la efectividad y costo de esta medida de control en base a la incidencia anual, la prevalencia y la prevalencia acumulativa a 20 años, indíca que la vacunación especifíca a altos niveles de cobertura es el método de control más efectivo a largo plazo para reducir la incidencia de lepra. Si puede cubrirse el costo de la campaña de vacunación durante los primeros años (el cual es aproximadamente 4 veces más alto que el de la estrategia actual), la vacunación específica es el método más "costo-efectivo" cuando se requieren altos niveles de efectividad. Aún si se toman como indicadores a la prevalencia o a la prevalencia acumulativa, la vacunación específica sigue siendo el método más conveniente para el control de la lepra. La vacunación con BCG no sólo es menos efectiva sino también menos "costo-efectiva".

En condiciones de serios problemas presupuestales, el reducir la deserción al tratamiento (en el modelo se ha simulado aumentado el grado de reinicio del tratamiento) y la detección más temprana de los casos, parecen ser medidas útiles en el control. Sin embargo, su efectividad final en términos de reducción de la incidencia es muy pequeña. Como se esperaba, la segregación es costosa e inefectiva comparada con otros métodos. En cada simulación, el costo para tratar a los pacientes ya enfermos o en periodo de incubación es elevado en el tiempo en el que se inician las medidas de control. Los métodos diseñados para reducir la transmisión (vacunación, tratamiento temprano o segregación) tienen efectos retardados sobre los costos aún si se logra reducir la incidencia. El aspecto más costoso en estas medidas de control, es el tratamiento prolongado o aún de por vida de los pacientes. El desarrollo de tratamientos efectivos de acción rápida es, probablemente, la única forma de reducir los costos a corto plazo. Por esto, aparte de las investigaciones sobre el desarrollo de una vacuna especffica contra la lepra, deben incrementarse los recursos para el desarrollo de nueva terapéutica.

RÉSUMÉ

L'efficacité de diverses méthodes de contrôle de la lèpre, mesurée selon l'effet qu'elles exercent sur l'incidence de la maladie, a été étudiée sur une période de 20 ans. Les incidences ont été comparées avec les incidences prédites lorsque l'on utilise la méthode actuelle de contrôle, basée sur un diagnostic précoce et un traitement de masse. La vaccination de l'entièreté de le population par un vaccin spécifique, mesure de contrôle qui n'est pas encore mise au point, a cependant été identifiée comme susceptible d'être la stratégie la plus effective à long terme. Une analyse coût-efficacité a été menée en utilisant trois indicateurs d'efficacité, à savoir l'incidence annuelle, la prévalence annuelle, et la prévalence cumulée sur une période de 20 ans. Ces indicateurs ont été alors étudiés en fonction des coûts cumulatifs. Cette analyse a révélé que la vaccination par un vaccin spécifique, appliquée à un pourcentage

élevé de la population, serait la méthode la plus efficace pour contrôler l'incidence à long terme. Si l'on peut assumer le coût d'une campagne de vaccination au cours de la première année (soit environ 4 fois le coût requis pour déployer la stratégie actuelle) la vaccination par un vaccin spécifique demeure la méthode la plus avantageuse au point de vue du coût-efficacité, lorsqu'il s'agit d'achever un niveau élevé d'efficacité. La vaccination par un vaccin spécifique reste la méthode la plus avantageuse lorsque l'on prend la prévalence ou la prévalence cumulée comme indicateurs de l'efficacité des méthodes de lutte contre la lèpre. La vaccination de type BCG n'est pas seulement moins efficace, elle est aussi moins avantageuse sur le plan coût-efficacité. Une réduction du taux d'abandon au traitement, qui dans le modèle a été simulée en accroissant le taux de reprise en traitement chez les malades l'ayant auparavant abandonné, de même qu'une détection précoce, sont apparues comme des méthodes utiles, dans des conditions de restriction budgétaire sévère. Leur efficacité finale en terme de réduction d'incidence est cependant très faible. Ainsi que l'on pouvait s'y attendre, l'isolement est coûteux et inefficace comparé aux autres méthodes.

Pour toutes les simulations, le coût du traitement du grand nombre de malades déjà atteints de lèpre, ou infectés par la maladie et encore en incubation, au moment où les mesures de contrôle simulées sont mises en oeuvre, est fort élevé. Les méthodes qui visent à réduire la transmission, telles que la vaccination, un traitement plus précoce ou l'isolement, ont des effets prolongés sur le coût, même si l'incidence est diminuée. Le traitement prolongé, ou même durant toute la vie, des malades constituent le poste le plus important sur le plan financier.

Le développement de traitements efficaces et d'action rapide apparait comme la seule méthode permettant de réduire le coût à court terme. Dès lors, outre le développement de recherches visant à mettre au point un vaccin pour la lèpre, il faudrait également prévoir des ressources pour développer de nouvelles thérapeutiques.

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