ANALYTICAL TOOLS FOR PLANNING COST-EFFECTIVE SURVEILLANCE IN GAMBIENSE SLEEPING SICKNESS

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ABSTRACT • The re-emergence of sleeping sickness as a major health problem in parts of Africa, combined with the new sources of financial support and provision of drugs means that an investigation of the cost-effectiveness of the different approaches is timely. There has been very little work done on the economics of controlling either form of sleeping sicksness. This paper builds on work done for WHO by the authors on developing a framework for analysing the cost-effectiveness of different methods for surveillance in gambiense sleeping sickness. The framework has been used to build a spreadsheet which makes it possible to simulate the effects of controlling the disease at different prevalences, for example using mobile teams or various forms of fixed post surveillance and screening different proportions of the population in a year. Prices, control strategies, prevalence, sensitivity and specificity of tests are all variables which can be altered to suit different situations or investigate how different approaches perform. As new research is beginning to produce calculations of the burden of sleeping sickness, in terms of disability-adjusted life years (DALY) potentially averted by controlling the disease, it is possible to combine these DALY estimates with the analyses of cost-effectiveness undertaken in these exercises to look at the cost-utility of the work, both to compare different approaches and demonstrate that controlling sleeping sickness represents good value for money as an investment in health.

KEYWORDS • Human African trypanosomiasis - Surveillance - Gambiense sleeping sickness - DALY's - Cost-effectiveness - Mobile teams - Health care delivery.

OUTILS POUR LA PLANIFICATION ET L'ANALYSE DU COUT-EFFICACITE DES PROGRAMMES DE LUTTE ET DE SURVEILLANCE CONTRE LA FORME *GAMBIENSE* DE LA MALADIE DU SOMMEIL

RESUME • Par suite de la résurgence de la maladie du sommeil en tant que problème de santé publique majeur dans certaines régions de l'Afrique et de la mobilisation de nouvelles ressources financières et thérapeutiques, il apparaît opportun de ré-évaluer le coût-efficacité des différentes approches. Il y a peu d'études concernant les aspects économiques de la lutte contre l'une ou l'autre forme de la maladie du sommeil. Cette étude fait suite aux travaux que les auteurs ont réalisés pour l'OMS dans le but de mettre au point une structure d'analyse de rentabilité des différentes méthodes de surveillance de la forme gambiense de la maladie du sommeil. Ce travail a abouti à la construction d'une modélisation informatique qui permet de simuler les effets de la lutte contre la maladie selon le taux de prévalence ; par exemple, en utilisant des équipes mobiles, ou différente formes de surveillance en poste fixe et le dépistage dans différents échantillons de la population pendant l'année. Les prix, les stratégies de lutte, les taux de prévalence ainsi que la sensibilité et la spécificité des tests diagnostiques sont autant de variables qui peuvent être modifiées soit pour se conformer à une situation donnée soit pour évaluer la performance de différentes approches. Grâce à des travaux de recherche récents qui ont calculé le coût de la maladie en termes de DALY, il est maintenant possible de combiner ces estimations de DALY avec les analyses du coût-efficacité décrites ci-dessus pour évaluer le coût-utilité des différentes méthodes de surveillance et pour démontrer que la lutte contre la maladie du sommeil représente un investissement en santé humaine très rentable.

MOTS-CLES • Trypanosomiase humaine africaine - Surveillance - *Trypansoma gambiense* - DALY - Coût-efficacité -Equipe de surveillance mobile - Prise en charge sanitaire.

As a subject, human African trypanosomiasis seems to have been overlooked by health economists. The great campaigns of the colonial era were undertaken largely on the basis of what was feasible, with the considerable resources that could then be mounted to stage military style control campaigns. Active surveillance has been continued as far as possible since then, but recent decades have seen health services struggling to meet many conflicting demands from a constantlyshrinking financial resource base. Political instability and war have made it all but impossible to work in many of the sleeping sickness endemic areas. Only 3 to 4 million out of the 60 million people who are estimated to be at risk are under any form of surveillance (1), either involving active screening or access to a health facility which can diagnose the disease. Despite the very low levels of surveillance, there has been a well-documented resurgence of the disease, with the number of cases being found annually rising to about 45000. This compares with around 4500 in the 1960's when there was still widespread active surveillance (2). By the 1970's the number of cases found had

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risen to about 7 000 a year, and since then there has been a steady increase. It is estimated that at least 300 000 to 500 000 people are currently infected (1).

Until very recently the picture seemed to be one of unrelieved bleakness - with no prospect of finding the funds for more active surveillance work, even in well known endemic foci, the cessation of production of DFMO, and uncertainty hanging over the continued production of the remaining drugs for treating the disease. In this climate, there seemed to be little point in analysing the cost-effectiveness of different approaches towards controlling the disease - apart from the areas where NGO's were active in controlling the disease - for many health services it was often simply a matter of undertaking what little active surveillance was possible whenever some funds could be obtained, or of fire-fighting, by responding to the situation in areas where numbers of new patients had been found.

However, great positive changes occurred in the first half of 2001, through the announcement that DFMO production was to be continued, a grant from the Bill and Melinda Gates Foundation to support the development of a new drug for treating the first stage of the disease and the announcement of $25 million of support for the control of the disease over the next five years from Aventis Pharma. In this more positive economic situation, an analysis of the financial implications and cost-effectiveness of different strategies to control the disease has the potential to contribute significantly towards effective planning and monitoring of control work.

In this context, there are three main areas that need to be addressed :

- analysis of which is likely to be the most cost-effective approach in a given situation ;
- determination of the financial resources needed to carry it out ;
- evaluation of the work done in order to assess impact, and improve the design of future work.

Finally, the results of such economic analyses should serve the needs of advocacy, providing more evidence of how cost-effective trypanosomiasis control is, in relation to other health investments, and thus making it easier to argue for adequate resources to be allocated to it by donors and by national health services.

BACKGROUND AND METHODOLOGY

For the disease in animals, a solid body of literature has gradually accumulated, mostly over the last two decades. This deals both with the impact of the disease on livestock (3) and the cost-effectiveness of different approaches to controlling the disease (4), and includes numerous cost-benefit studies. However, despite the vast experience gained by a century of control activities, there have been very few studies or publications explicitly analysing the economic or financial aspects of dealing with trypanosomiasis in humans and their impact on the incidence of the disease - most of these are listed as references to this paper. Nevertheless, the need to budget for the many programmes undertaken and the basic record keeping, supplemented with more structured epidemiological studies does mean that a great deal of information and knowledge already exist. A recent publication (5) has studied these aspects very successfully for malaria control, comparing the cost-effectiveness of insect treated nets, residual spraying, chemoprophylaxis for children and examining the economics of preventive interventions.

This paper builds upon work done by the authors for the previous WHO Expert Committee reports on African trypanosomiasis (6, 7) and on the paper prepared for the recent WHO Scientific Working Group on the disease (8). It also draws on the resources and methodology developed in a series of teaching exercises on the subject, in particular at the WHO/IMTSSA «First International Course on African Trypanosomoses» given in Marseille in 2000. The main emphasis has been on analysing the cost-effectiveness of different methods of surveillance for gambiense sleeping sickness. This is currently seen by WHO as the area where financial planning is urgently needed. Accordingly this paper again takes up this theme, illustrating the steps needed in order to calculate costs and look at indicators of cost-effectiveness and eventually, cost-utility. These calculations were then developed into a spreadsheet model which used the calculations in WHO (6) as a basis for illustrating the potential this approach has for contributing to decision-making and addressing the three areas described above.

The first of the two previous exercises in calculating the cost-effectiveness of various forms of surveillance was originally set out in Shaw and Cattand (9) using figures based on WHO's work in the Daloa area of Côte d'Ivoire. Four approaches to surveillance were analysed :

- systematic fixed post surveillance at rural health centres ;
- road blocks near centres, usually set up on market days to test people travelling in and out of the centre ;
- polyvalent mobile teams, undertaking surveillance for two other diseases as well as trypanosomiasis ;
- monovalent mobile teams, dealing only with sleeping sickness.

In the second exercise (10) the same methodology was used but the figures and prices used were based mainly on John's work in the Moyo District of Uganda (11). The surveillance strategies analysed were again polyvalent and monovalent mobile teams, and to these was added the less widely used innovative technique of filter paper sampling by trained community health workers, either visiting the community or based at rural health centres. The road block option was dropped, but, in order to provide a comparison with active surveillance, a passive surveillance option, where patients presenting with symptoms were eventually diagnosed at a clinic was added. The results of the analysis are given in a series of tables in Annex 9 of the WHO (6) expert committee report. Surprisingly, for those surveillance strategies that were costed out in both exercises - essentially the mobile teams - costs had only increased by 60 % over the ten year

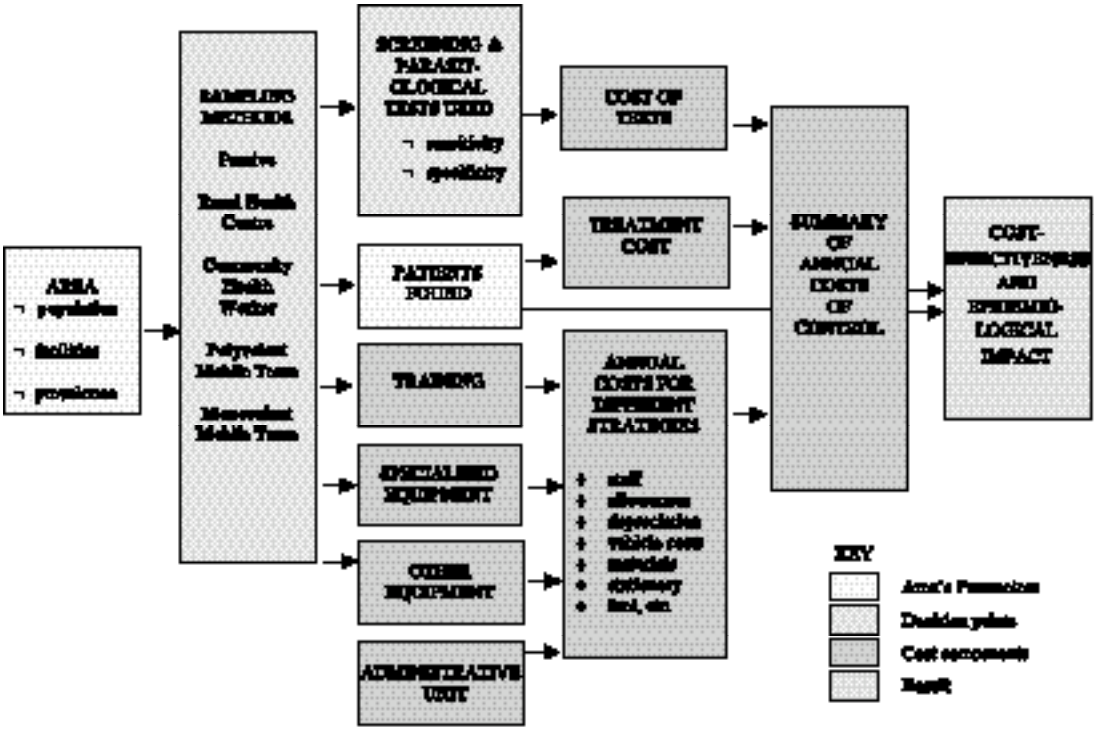

Figure 1 - Steps in the calculation process.

interval, perhaps reflecting the fact that in 1985 prices in Côte d'Ivoire were very high, whereas in 1995 prices in Uganda were mostly representative of the rest of the continent, and slightly lower than in some countries.

In order to provide a realistic basis for assessing the cost-effectiveness of the different approaches, both exercises :

- were based on conservative assumptions about the number of people who could be tested using the different surveillance strategies ;

- included the full costs of the work, rather than just the extra costs incurred when mounting a field operation, thus, taking staff costs as an example, instead of just including travel allowances, a share of the basic salaries of all staff, equivalent to the proportion of the time they spent working on the disease, was calculated and incorporated in the costings ;

- calculated depreciation on all equipment used for the various operations, including a share of depreciation on equipment which was also used for other disease control activities.

Having developed a standardised approach to the calculations, the process of building up a coherent and comparable set of costings which could be used to calculate cost-effectiveness involved a number of steps, which are illustrated in figure 1. Its apparent complexity is due to the need to integrate information about the study area, the disease and the cost components, which include costs not directly undertaken as part of the surveillance activity, such as training, administration and hospitalisation. The calculations and assumptions to be made break down into three main steps :

- defining the area which will be surveyed, its human population, medical facilities and expected disease prevalence and constructing the surveillance strategies to be evaluated ;

- determining what tests are to be used, and estimating their field sensitivity and specificity ;

- analysing the likely costs of treatment.

SAMPLING STRATEGIES AND STUDY AREA

The original analyses were based on five alternative surveillance strategies :

- Fixed-post or passive surveillance, where patients presenting with symptoms that are difficult to diagnose or don't respond to treatments, say for malaria, are eventually referred to a treatment centre and tested for a variety of diseases, including trypanosomiasis, and those with the disease are eventually diagnosed. The initial screening test is performed on wet blood.

- Filter paper sampling at rural health centres, where community health workers based at rural health centres receive some training in collecting samples on filter paper and then routinely test any new patients presenting themselves at the health centre for whatever reason.

- Filter paper sampling by community health workers, who have been trained in collecting filter paper samples and then spend 20% of their time collecting samples and following up seropositive individuals. This was based on experience in Uganda (11) and Cote d'Ivoire (12). However, this approach turned out to be less promising than was hoped, and is retained here mainly to give an idea of how a surveillance strategy based on community health workers might compare with the other approaches.

Table I - Numbers screened for trypanosomiasis using different surveillance strategies in an area with a population of 100 000.

Surveillance Strategy	Fixed-post surveillance	10 Rural Health Centres	20 Community Health Workers	One monovalent mobile team	One polyvalent mobile team
Number screened per annum	300	3 000	24 000	36 000	20 000

- Monovalent mobile teams, the classic surveillance teams; in this scenario the CATT is performed on whole blood, and all the parasitological tests except for lumbar punctures are done by the team in the field. The monovalent teams work only on trypanosomiasis.

- Polyvalent mobile teams, which operate in the same way as monovalent teams, except that only a third of their work consists of screening for trypanosomiasis.

- In order to standardise the results, these were calculated for an area with a human population of 100 000 people, containing ten rural health centres, and where 20 community health workers were operating. The numbers screened by each strategy were assumed to be as given in table I.

SEQUENCE OF TESTS USED

Initial screening was assumed to be using the CATT on whole blood, except for the work by community health workers where the CATT was used on samples collected on filter paper. The interplay of the test sensitivity and specificity is important, especially in low prevalence situations where the proportion of patients among those testing positive is low.

For parasitological confirmation, the tests used were (in ascending order of cost) lymph node punctures, for those with swollen glands, CTC and m-AECT. Depending on the protocol used in an area, some or all of these tests may be used, and lumbar punctures may be undertaken on sero-positive individuals in whom the parasite has not been detected using other methods. Obviously, lumbar punctures are also required to test for stage of the disease.

There is scope for sensitivity analysis on the cost-effectiveness of using the different tests in different sequences. In high prevalence situations, it may take a long time to run a variety of tests on every seropositive individual. At low prevalences, the difficulty of finding a small number of patients among a large number of people testing positive may mean that it is desirable to use as many tests as possible.

TREATMENT COSTS

Treatment costs, for those correctly diagnosed, either when they present themselves with symptoms «passively'» or when they are found as the result of active surveillance, were estimated in WHO (6) and are given in table II, on the basis of then current drug costs, treatment regimes in use and estimates of the cost of hospitalisation. These costings will need to be re-evaluated in the light of current plans to make drugs available at handling cost from WHO since drugs are being provided free of charge by the manufacturer for a specified number of years. For the relevant drugs the amount paid by recipient countries or programmes will consist only of cost pertaining to storage, packing and transport as well as drug administration, so that, as the table indicates below, treatment costs could be reduced by significant percentages. Nevertheless, in economic as against purely financial terms, the use of these drugs will still represent a resource cost, which should be taken into account. Furthermore, their availability on these terms will change over time.

MODELLING THE COST-EFFECTIVENESS OF DIFFERENT SURVEILLANCE STRATEGIES

A spreadsheet was then developed, following the structure of figure 1, using Microsoft ® Excel. The basic data set required is given in table III. All these data items also act as variables, so that either different situations and different price sets can be analysed or else the cost-effectiveness of different approaches (surveillance strategies, parasitological tests, sampling intensity) can be tested. There follows a series of graphs which illustrate how the model can be used to analyse cost-effectiveness. Obviously the number of variables is such that the sensitivity of the results with respect to any number of assumptions, price changes and different situatations can be simulated. The model runs illustrated here examined three things :

Table II - Costs of treatment US$ (source: WHO, 1998).

	First-stage disease		Second-stage disease	
Item	Pentamidine	Suramine	Melarsoprol	Eflornithine
Estimate of total cost	107	114	253	675
Cost excluding drug cost	87	79	190	367
Drug cost as % of total cost	19	31	25	46

Table III - Basic data set for cost calculations.

Population and medical services
- Number of people in the target area
- Number of rural health centres
- Number of sampling units (e.g. mobile teams)
- Number of treatment centres

Disease situation
- Expected prevalence
- Expected proportion of patients found in 1st and in 2nd stage of disease

Performance of sampling strategies
- Number of people screened per year by one sampling unit
- Percentage of those who test positive at any stage accepting further testing or treatment
- Where the sampling unit deals with other diseases (rural health centre, polyvalent mobile team) the share of the human and material resources which are normally allocated to trypanosomiasis control

Tests used
- Initial screening test, its field sensitivity and specificity
- Sequence of tests for parasitological confirmation, their sensitivity (in terms of what proportion of patients are likely to be found at each stage in the sequence)

Cost information
- Unit cost of screening test
- Unit cost of parasitiological test(s)
- Cost per sampling unit and useful life of specialised equipment purchased for trypanosomiasis control and not shared with other disease control work, so that annual depreciation can be calculated
- Cost per sampling unit and useful life of other equipment that is shared with other disease control work, so that annual depreciation can be calculated
- Cost per person trained on trypanosomiasis work and useful life (number of years before training needs to be repeated and/or people move on to other activities)
- Annual cost per sampling unit for necessary administrative back-up
- Other annual running costs per sampling unit
- Treatment costs for patients in the first stage of the disease
- Treatment costs for patients in the second stage of the disease

- the relative performance of the five strategies as costed out in WHO (6) with some minor revision to prices;

- the effect of changing prevalence, looking at a wide range (0.1 % to 70 %);

- the effect of using variable numbers of mobile teams.

Cost of finding patients.

Firstly, the relative performance of the different surveillance strategies in terms of the cost of finding gambiense patients was analysed. The results, in terms of US$ per trypanosomiasis patient found, are given in figure 2. Obviously the cost of finding a patient declines very rapidly as the prevalence increases, since a higher proportion of those screened are infected. This clearly does not reflect any increase in efficiency, simply that more and more of those screened are infected, so the costs of the operation are averaged out over a larger number of individuals. Figure 2 is given in three sections, so that the differentials between the costs of each sampling strategy can be seen more clearly.

Thus, at very low prevalences, 1 % or less, see figure 2a, such as those encountered in past years in areas where surveillance was reasonably regular, and the disease was considered to be under control, the costs at, for example, a 0.05 % prevalence are well over US$ 2000 per patient found using rural health centres or mobile teams, and drop to just under US$ 2000 for community health workers. Passive or fixed-post detection costs only US$ 50, since there are virtually no overheads. When the prevalence reaches 1 %, the cost of passive detection falls to just over US$ 20 per person, surveillance using community health workers costs just under US$ 100 per person, and using mobile teams or rural health centre costs between US$ 120 and US$ 140.

At medium level prevalences, from 1 % to 5 %, see figure 2b, these costs per patient found continue to fall, and the differentials between strategies narrow further, with the cost of passive detection being US$14, community health workers US$ 22 and the other three options about US$ 30.

At higher prevalences, over 10 %, see figure 2c, the cost of patients found falls to around US$ 10, for all surveillance strategies at prevalences over 20 %. When the prevalence reaches 50 %, the cost of detection becomes very low, around US$ 5 for all surveillance strategies, except passive detection where it remains at about US$ 10.

Given the way in which the figures were calculated, by independently building up the cost of each strategy using local norms and prices, it was surprising how similar the costs for finding patients using different strategies were. Setting aside passive detection, of the four active detection strategies, community health workers using filter paper consistently appeared to be the most cost-effective. However, in the field, this strategy, although initially promising, proved unworkable on a larger scale. The mobile team concerned only with trypanosomiasis surveillance was also consistently the most costly.

The almost total convergence of costs at high prevalences is due to the fact that at higher prevalences more than half of all costs are diagnostic costs for initial screening and parasitological examinations (ranging between US$ 3.50 and US$ 2.50 per person). At these prevalences, most individuals are sero-positive and have to be re-examined and the running cost and overheads associated with each strategy are spread over a large number of patients.

Epidemiological impact .

In order to further examine the relative effectiveness of the different surveillance strategies in figure3 shows what proportion of the population could be sampled in a year using different approaches. This reflects the assumptions made about the possible workload that each form of active surveillance can tackle. The figure shows the situation if, in the hypothetical area with a human population of 100000, the number of rural health centres is fixed at 10 and, for comparison purposes, the number of community health workers who can assign a significant proportion of their time to active case detection for sleeping sickness was assumed to be 20. Thus it is only the inputs by the mobile teams which can be increased as illustrated, from spending half their time in the area to

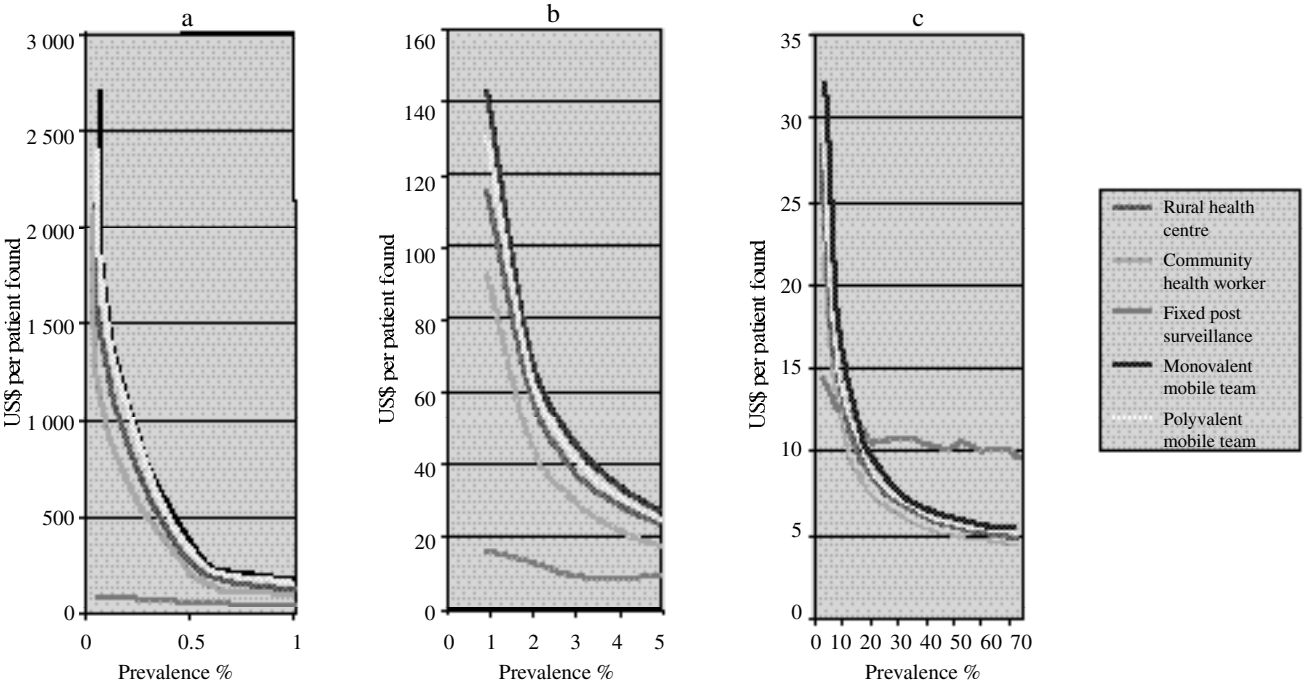

Figure 2 - a) Cost of detection per patient at low prevalences : 0.01 % to 1 % ; b) Cost of detection per patient at medium prevalences : 1 % - 5 % ; c) Cost of detection per patient at high prevalence : 5 % and over.

having two teams working there. Based on experience, it was also assumed that the mobile teams were able to undertake further examinations on a higher proportion of CATT+ patients than was possible under the other surveillance strategies based on community health workers. The filter paper based sampling strategies involve a delay before the results are known and individuals testing positive then have to be recalled and taken to a treatment centre for further testing, which seriously compromised their effectiveness. The mobile teams can undertake many of the parasitological tests themselves, and then transport the remaining individuals to a treatment centre for final confirmation of their disease status.

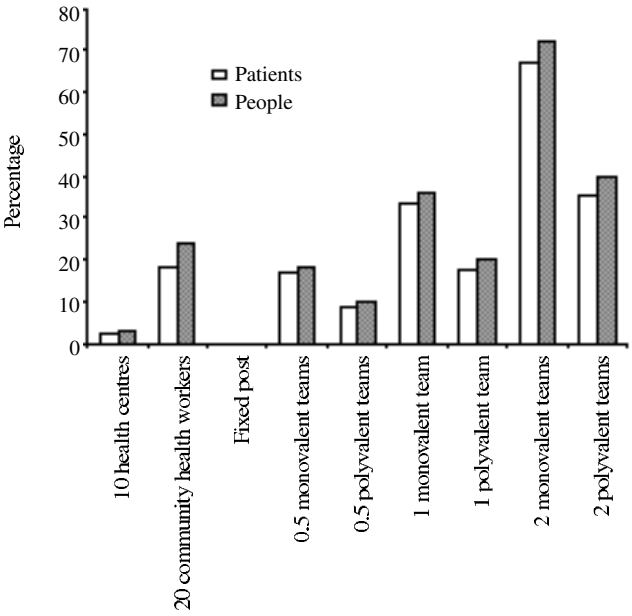

Figure 3 - Percentage of population sampled and percentage of all try - panosomiasis patients found according to surveillance strategy used.

Under these conditions, as illustrated in figure 3, finding and treating a majority of the patients in the population can only be done using one or more monovalent mobile teams. The other active surveillance strategies could be effective in detecting the presence of the disease or gradually eroding the size of the human reservoir, provided that the incidence is not high.

The nature of the financial resources required.

Turning from the costs per individual found with the disease, to the total investment required for finding trypanosomiasis patients, figure 4 illustrates these for the five different surveillance strategies for prevalences of 1 % and 10 %. As would be expected, the costs largely reflect the proportion of the population screened by each strategy, see figure 3 and table II. Although costs would vary from country to country, and have probably increased somewhat since these figures were produced in 1998, they give an idea of the orders of magnitude involved, ranging from US$ 50 000 to US$ 60 000 for a monovalent mobile team, to a minimal investment for fixed post/passive detection.

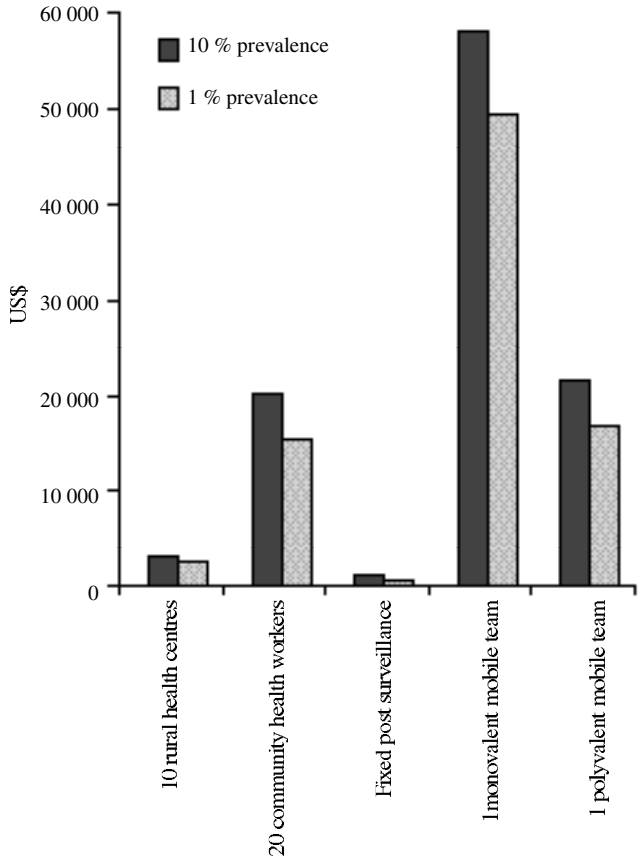

Figure 4 - Total trypanosomiasis specific costs by surveillance strategy.

In order to better understand how the situation evolves at high prevalences, details of the calculation for intervention by a mobile team are shown below, in figure 5. The cost of treating the patients found has now been added to produce total costs. These have been broken down into four categories. The cost of surveillance (logistics, share of salaries, etc.) is given as 'sampling strategy'. Diagnostic tests covers both initial screening and parasitological confirmation. These costs dominate total costs at very low prevalences, once a prevalence of 1% is reached, then all other costs are dwarfed by the cost of treating patients. Given the uncertainty about how to value drug costs, these have been included at their recent commercial cost, but separated from other treatment costs (administration of drugs and hospital care). Thus the graphs can be read so as to exclude the cost of drugs. A notional figure for transport or for their economic cost could be added in subsequent analyses.

The costs of controlling the disease in the area postulated, with one monovalent mobile team screening 36 % of the population in a year, thus range from just over US$ 50000 where the prevalence is 0.1 % to over US$ 4 million at a prevalence of 70 %.

This analysis thus examines the ways in which the costs of controlling the human reservoir vary with sampling strategy, sampling intensity and prevalence. The spreadsheet model produced provides a basis for extending this analysis to cover other surveillance protocols, price sets, test sensitivities etc. The figures used, it will be remembered, were based on conditions in Uganda, and were extrapolated from the situation encountered there. It is likely that the costings for the extremely high prevalences need revising upwards, since in the model the labour and time requirements have not been fully adjusted to deal with the work involved in a situation where virtually all individuals test positive to the screening test and need parasitological confirmation.

DALY'S AND THE COST-EFFECTIVENESS OF SLEEPING SICKNESS CONTROL

Finally, in order to examine the wider economics of controlling sleeping sickness in relation to the control of other diseases, an estimate of the cost per DALY averted is needed. So far there have been very few comprehensive attempts to calculate the actual and potential DALY's lost due to either form of sleeping sickness.

Recent work in Uganda has produced calculations of DALY's for rhodesiense (13, 14). The authors point out that the age distribution of trypanosomiasis patients very closely follows that of the active adult population. This means that the disease tends to strike the most economically productive group of society hardest, so that family livelihoods and community prosperity are much affected. This data confirms observations made throughout Africa for both forms of the disease. The authors estimate and that at the time of diagnosis, patients have been suffering from symptoms of the disease for an average of 61 days, they then require hospitalisation for an average of 34 days and that for patients correctly diagnosed and treated the case fatality rate is 5.3%. For unreported cases, the outcome is assumed to be inevitably fatal. Based on the age distribution of patients, the authors estimate that the number of DALY's for unreported and thus untreated patients is just over 20 years (personal communication Dr. Paul Coleman). This DALY figure thus also means that the cost-effectiveness of rhodesiense sleeping sickness control compares very favourably with those of other high priority health control activities, such as malaria (5) EPI, HIV.

For gambiense, there have been no published DALY figures based on detailed field records, An attempt to look at the economics of alternative treatments for second stage gambiense patients used the age-at-death distribution calculated for rhodesiense patients in Uganda (15). This article also concluded that the standard treatment for second stage patients represented a very attractive cost per DALY averted, ranking with the most cost-effective interventions such as childhood immunisation and blood-screening for HIV. However work is being undertaken on data collected in Southern Sudan and DALY's have been calculated. The initial results (16) very clearly indicate that that the cost of trypanosomiasis control based on surveillance falls well below the $ 25 per DALY which represents 'good value for money'.

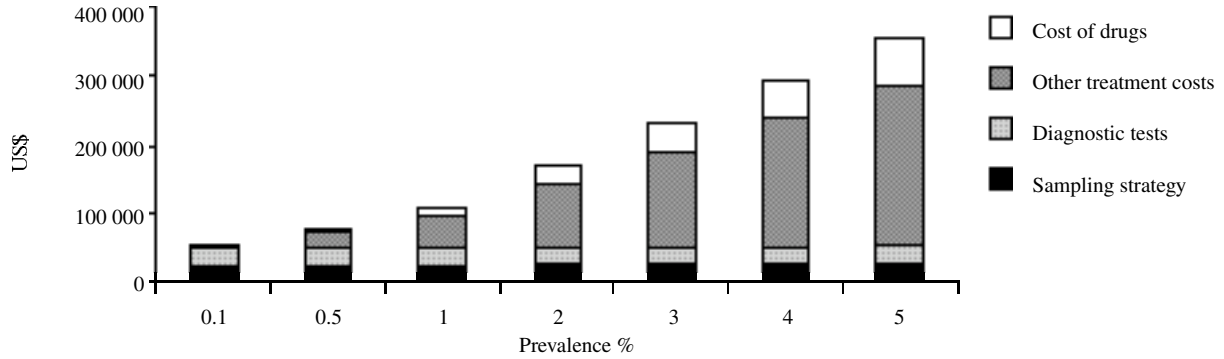

Figure 5a - Beakdown of costs of detection and treatment of patients at low to medium prevalences (one mobile team sampling 36.000 people).

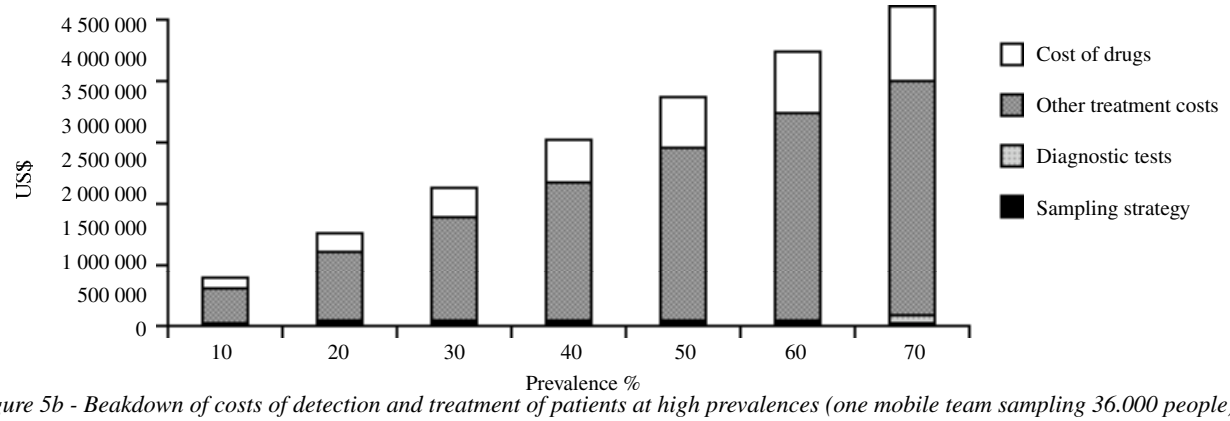

Figure 5b - Beakdown of costs of detection and treatment of patients at high prevalences (one mobile team sampling 36.000 people).

Figure 6 takes this discussion a bit further by modelling how the situation could be analysed with respect to different control strategies and different epidemiological assumptions. It takes the cost of treatment and detection of patients using a mobile team at different prevalences, as shown in figure 2, and divides it by a very conservative estimate of the number of DALY's averted whenever a patient is found and successfully treated. This (15 x 1) baseline figure, which gives the highest cost is based on each patient treated, that is premature death prevented, representing 15 DALY's averted. This figure was selected as a conservative estimate, taking into account the long asymptomatic period for gambiense disease and thus calibrated to be rather lower than the figure quoted for rhodesiense. On this estimate, once the prevalence has reached 1 %, when the cost per person found and treated falls to US$ 330, and thus the cost per DALY averted (US$ 300/15) is less than US$ 25, which is the generally recognised threshold below which health investments are thought to represent 'good value'. At higher prevalences, the cost per DALY averted stabilises at between US$ 10 and US$ 12.

In order to add another dimension to the analysis, three further lines have been drawn showing the effect if the number of DALY's averted per patient found and treated were multiplied by a factor of 1.5, 2 or 2.5. This thus looks at the sensitivity of the result to two factors influencing the cost-effectiveness per DALY :

- firstly, the assumption about the number of DALY's gained by finding and treating a patient - thus the line on the graph for 15 x 1.5 would be appropriate if calculations demonstrated that the real figure was likely to be 22.5 years;

- secondly, the effect on the transmission rate of controlling the human reservoir, if each infected person is likely to infect one other during the lifetime he would have had if untreated, then the line for 15 x 2 represents the cost per DALY of controlling the disease.

This second point brings the discussion back to epidemiology, since, at low prevalences, the additional cases prevented by curing individuals could be seen as a link to Ro, the measure of the basic reproductive rate of the disease.

There is thus a clear agenda for analysing existing data on the progress of epidemics and for collecting new data, in order to add to the knowledge of the epidemiology of the disease. The low proportion of all cases, which are actually recorded, has meant that knowledge of the year to year changes in prevalences is often patchy or anecdotal, nevertheless, for foci which have been the subject of more intensive control work over a number of years data does exist. In this context, epidemiological models (17) have an important role to play.

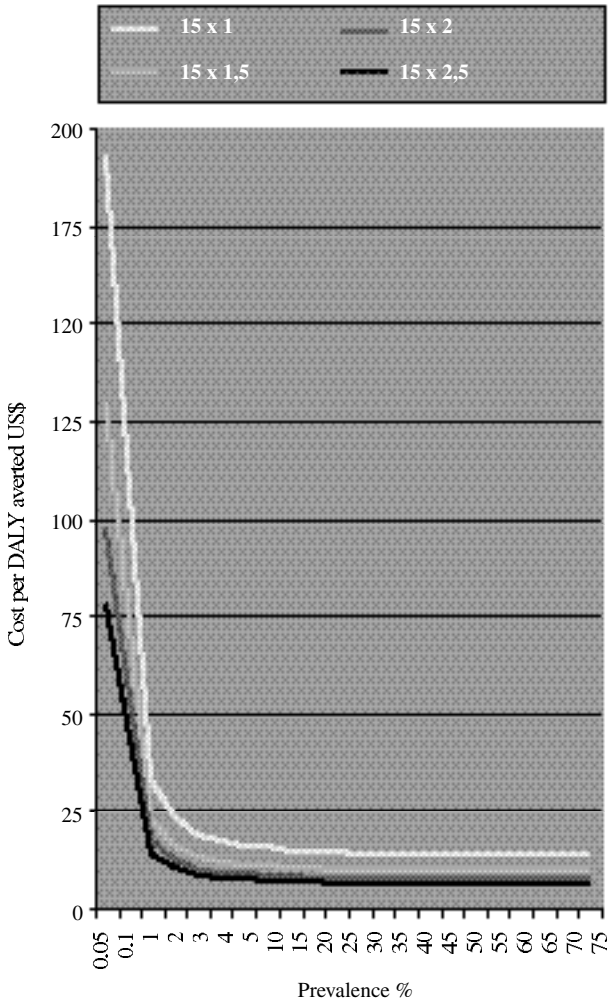

Figure 6 - Cost per DALY averted in US$ at different prevalences (sampling using a monovalent mobile team).

DISCUSSION

This paper has been more concerned with setting up a framework for analysing the cost-effectiveness of different surveillance strategies for gambiense sleeping sickness than with producing definitive numerical answers. Nevertheless, the modelling exercise has illustrated some clear relationships which have implications for planning.

In terms of choice of strategy, it seems that although the monovalent mobile team is apparently the most expensive, it is also the only technique which enables sufficiently intensive surveillance and case-detection to take place for there to be a significant effect on the human reservoir of the disease and thus for the disease to be controlled. This confirms received wisdom from field workers over a long period, in that effective control of the disease is only possible using dedicated teams targeting trypanosomiasis, and is difficult to integrate with other health service activities. Other approaches have a role to play in supporting the work of mobile teams, or in detecting changes in the incidence of the disease.

This raises the issue of whether the objective of a particular surveillance exercise is to control the human reservoir, to detect the presence of the disease, or to monitor change in incidence. Cattand et al. (1) set out a very clear step by step basis for mapping foci, prioritising control activites and organising them at different levels of intensity. A next step in refining the cost-effectiveness framework outlined in this paper would be to determine what the basic data set, see table III, would be for situations where reactive surveillance is currently planned and then to draw up surveillance approaches which conform exactly to the steps outlined in the Cattand et al. paper.

Another issue which has not been dealt with explicitly in this analysis is the timing and frequency of control activities. Trowbridge et al. (16) studied the relative cost-effectiveness of a crisis intervention as against more regular screening and treatment activities, and concluded that regular surveillance, in their example, at three year intervals, was the more cost-effective. The framework developed here shows how to calculate the costs for one annual intervention, for different starting prevalences. By doing repeated runs of the model to simulate repeated screening and treatment exercises at different prevalences, the effect of work over a number of years could be modelled and the cost-effectiveness of different screening frequencies analysed. However, such an exercise would depend crucially on the availability of data on the likely impact of repeated screening and testing on prevalence. As mentioned before, this requires epidemiological knowledge underpinned by historical data in order to make assumptions about how the prevalence changes from year to year with and without intervention, for a disease, which is notorious for its idiosyncratic behaviour. However, modelling the sensitivity of the results in response to various assumptions could illustrate what are likely to be the most cost-effective options.

Finally, from the point of view of those allocating funds within the health sector, the recent emergence of DALY calculations for sleeping sickness has made it very clear that control of this disease represents an extremely cost-effective investment. This is linked to two factors. The first is the fatal outcome of the disease in untreated patients. The second is due to the focal nature of the disease, which means that although the population at risk is large, the disease is nevertheless location specific, so that control operations can target circumscribed geographical areas where the disease is known to be present ■

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REFERENCES

1 - CATTAND P., JANNIN J., LUCAS P. - Sleeping sickness surveillance: an essential stepf towards elimination. *Trop. Med. Int. Health* 2001 ; **6** : 348-361.

2 - WHO - African trypanosomiasis - WHO report on global surveillance of epidemic prone infections, 2001, www.who.int.

3 - SWALLOW B.M. - The Impacts of trypanosomiasis on African agriculture. PAAT Position Paper 2. pp. 47, originallypresented (1997) ISCTRC Public. n° 119, 24th Meeting., Maputo, Mozambique, 1999, pp 515-536.

4 - BARRETT J.C. - Economic issues in trypanosomiasis control. Bulletin 75, natural resources institute. Chatham Maritime ed., UK, 1997, pp 183.

5 - GOODMAN C., COLEMAN P., MILLS A. - Economic analysis of malaria control in sub-saharan Africa. Strategic research series, global forum for health research, WHO, 2000.

6 - WHO - African Trypanosomiasis : control and surveillance. Report of a WHO expert committee. *WHO Technical report series* 1998 ; **881** : 1-123 .

7 - WHO - Epidemiology and control of African trypanosomiasis : control and surveillance. Report of a WHO Expert Committee. *WHO Technical report series* 1986 ; 739 : 3-144.

8 - SHAW A.P.M., CATTAND P., COLEMAN P.G., JOHN M. - A basis for financial decision-making on strategies for the control of human African trypanosomiasis. Paper prepared for the WHO scientific working group on African trypanosomiasis, Geneva, Switzerland, 2001, 04-08 June, 2001.

9 - SHAW A.P.M., CATTAND P. - The costs of different approaches towards the control of human African trypanosomiasis. Paper prepared for the WHO expert committe on the epidemiology and control of African trypanosomiasis, 1985, Ref. TRY/EC/WP/85.17.

10 - SHAW A.P.M., JOHN M., CATTAND P. - The financial implications of different approaches to the detection and treatment of human African trypanosomiasis, paper prepared for the WHO expertcommittee on the epidemiology and control of African trypanosomiasis, 1995, Ref. TRY/EC/WP/95.14.

11 - JOHN M. - Utilisation of testryp CATT applied to samples of dried blood for sleeping sickness screening (*T. b. gambiense* trypanosomiasis) of the population in villages and health units, Moyo district, Uganda, 1995, 1993-1994.

12 - LAVEISSIERE C., DOUA F., MIEZAN T. et Coll. - Intégration de la surveillance de la maladie du sommeil aux Soins de Santé primaires dans le foyer de Sinfra (Côte d'Ivoire). OCCGE, Institut Pierre Richet, Bouaké, Côte d'Ivoire, 1995.

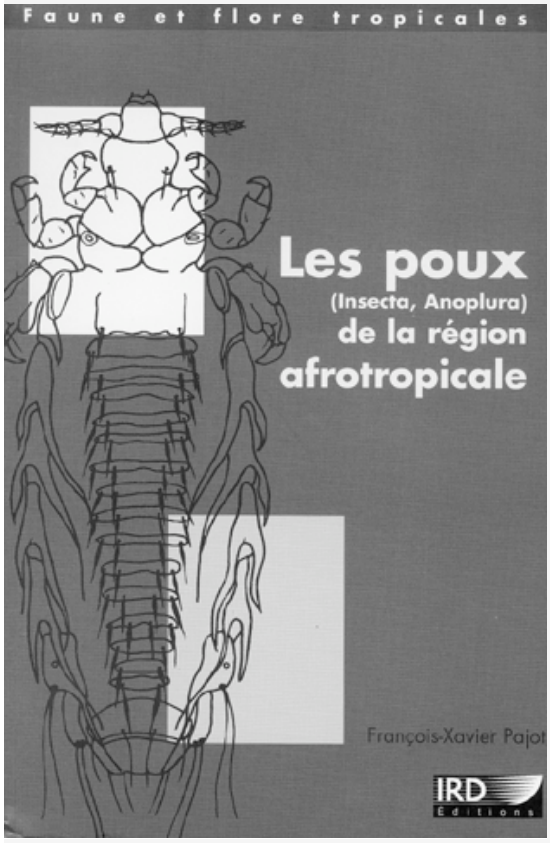
13 - ODIIT M., FEVRE E. M., MAGONA J. et Coll. - Incorporating the burden of human sleeping sickness in an economic impact assessment of trypanosomiasis. ISVEE ed., Colorado, 2000.

14 - ODIIT M., FEVRE E. M., COLEMAN P G. et Coll. - The Burden of sleeping sickness in southeastern Uganda - geographical variations. Paper presented to the *British Society of Parasitology,* Oxford, 2000.

15 - POLITI C., CARRIN G., EVANS D.et Coll. -Cost-effectiveness analysis of alternative treatments of African gambiense trypanosomiasis in Uganda. *Health Economics* 1995 ; **4** : 273-287.

16 - TROWBRIDGE M., MCFARLAND D., RICHER M. et Coll. - Cost-effectiveness of programs for sleeping sickness control. *American Society of Tropical Medicine and Hygiene,* 49th Annual Meeting, Houston, TX, 2001, 2000, Abstract 417.

17 - ROGERS D.J. - A general model for the African trypanosomiases. *Parasitology* 1988 ; **97** : 193-212.



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Mots-clés • Poux (anoploures) - Région afrotropicale - Systématique - Hôte - Répartition.