Cost-effectiveness analysis of humanitarian relief interventions: visceral leishmaniasis treatment in the Sudan

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Spending by aid agencies on emergencies has quadrupled over the last decade, to over US$ 6 billion. To date, cost-effectiveness has seldom been considered in the prioritization and evaluation of emergency interventions. The sheer volume of resources spent on humanitarian aid and the chronicity of many humanitarian interventions call for more attention to be paid to the issue of ‘value for money’.

In this paper we present data from a major humanitarian crisis, an epidemic of visceral leishmaniasis (VL) in war-torn Sudan. The special circumstances provided us, in retrospect, with unusually accurate data on excess mortality, costs of the intervention and its effects, thus allowing us to express cost-effectiveness as the cost per Disability Adjusted Life Year (DALY) averted.

The cost-effectiveness ratio, of US$ 18.40 per DALY (uncertainty range between US$ 13.53 and US$ 27.63), places the treatment of VL in Sudan among health interventions considered ‘very good value for money’ (interventions of less than US$ 25 per DALY). We discuss the usefulness of this analysis to the internal management of the VL programme, the procurement of funds for the programme, and more generally, to priority setting in humanitarian relief interventions.

We feel that in evaluations of emergency interventions attempts could be made more often to perform cost-effectiveness analyses, including the use of DALYs, provided that the outcomes of these analyses are seen in the broad context of the emergency situation and its consequences on the affected population. This paper provides a first contribution to what is hoped to become an international database of cost-effectiveness studies of health interventions during relief operations, which use a comparable measure of health outcome such as the DALY.

Introduction

Spending by official aid agencies (DAC-countries) on emergencies has quadrupled over the last decade, to over US$ 6 billion.1 A considerable proportion of humanitarian aid is spent on provision of health care.

Numerous factors contribute to the decision of the international community to intervene in a particular humanitarian crisis. These factors range from apparent excess mortality, politically driven motives and media coverage, to the presumed effectiveness of the proposed intervention.

Cost-effectiveness analyses (CEA) have been introduced (and critically reviewed) to assist priority setting for health interventions in developing countries.2,3 These analyses have proven their added value to develop targeting strategies,4 as well as to compare different approaches to treatment.5,6,7,8 Although the first articles using CEA have appeared for choosing between strategies in refugee settings,9 CEA is still hardly ever considered in prioritization and evaluations of emergency interventions. The perceived effectiveness alone is viewed as more important. Furthermore, there are major methodological difficulties in measuring and interpreting cost-effectiveness.10 The sheer volume of resources spent on humanitarian aid and the chronicity of many humanitarian interventions call for more attention to be paid to the issue of ‘value for money’, or how best to allocate limited resources to achieve maximal health outcomes.

In this paper we present data from a major humanitarian crisis; an epidemic of visceral leishmaniasis in war-torn Sudan. The special circumstances provided us, in retrospect, with unusually accurate data on excess mortality, costs of the intervention and its effects, thus allowing us to express cost-effectiveness as the cost per Disability Adjusted Life Year (DALY) averted.

We examine the usefulness such cost-effectiveness data could have had in planning this particular health intervention and its application to priority setting in other circumstances.

Case study

Background

Civil war in Sudan has torn the country apart since 1983. It has had a devastating effect on the delivery of health care services. In addition, droughts and epidemics have plagued the country. Areas, difficult to reach in the past, have become completely isolated. One such area is Western Upper Nile (see Figure 1) with an estimated population of 300 000. The
main tribe is the semi-nomadic Nuer whose livelihood depends on cattle rearing supplemented by the cultivation of maize and sorghum, and occasionally fishing. The most prevalent health problems include malnutrition, malaria, tuberculosis, meningitis, schistosomiasis, diarrhoeal diseases, and acute respiratory infections. There are few safe water sources. Most water is taken from rivers or shallow wells. Many health facilities are no longer functional, and only a few drugs can be bought in the local markets.

In 1988, Médecins Sans Frontières (MSF) was requested to start an intervention to address some of the most urgent health needs in the area of Western Upper Nile. At the time, the accessibility to and within the region was restricted due to insecurity and a deteriorated infrastructure. Expatriates and all supplies had to be flown in by small aircraft, which flew every three weeks to the area, weather and security permitting. Particularly during the rainy season, access to surrounding villages was limited as roads were often impassable and destroyed bridges impeded river crossings. A base in Nairobi, staffed with two expatriates, took care of supplies, organization of transport, and communication.

The initial strategy was to provide basic health services by rehabilitating the dilapidated, small hospital in the central town of Ler and to set up simple health posts in ten surrounding villages. Maternal and child health services and curative care were offered for the most common illnesses, like malaria, acute respiratory infections and diarrhoea. Few qualified medical staff had remained in the area. Expatriate staff were deployed to assist in the hospital and to train auxiliary health workers for the hospital and the health posts. These basic health services are still operational to date, in 1998. In the five years between 1990 and 1994, 6413 patients were admitted to the hospital and 224 110 patients were treated in the outpatient departments. The health posts treated over 500 000 patients.

Over the course of time, two disease-specific programmes were added: in 1989 a visceral leishmaniasis treatment programme and in 1993 a tuberculosis treatment programme. The total costs of the interventions in Western Upper Nile between 1990 and 1994 amounted to US$ 8 135 015. Finances were obtained from MSF's private funds and external institutional donors. The only other external agency in the area at the time was the International Committee of the Red Cross, which was mainly involved in rinderpest immunization of cattle, food distribution, support to the Expanded Program on Immunization (EPI), and construction of wells.

**Visceral leishmaniasis (VL)**

In 1989 the deadly disease that was reported to rage in the inaccessible area north of Ler, was identified as VL, also known as Kala Azar. The disease was new to the area, striking a non-immune population against a background of near famine. It caused a massive number of deaths, while survivors left the area. Diagnosis and treatment were the only feasible measures to control the epidemic. Treatment centres were established, first in Ler, and later on in areas closer to the epicentre of the epidemic when they became accessible (Duar and Niemne). Typically, two to three expatriates supervised the treatment per centre, assisted by local staff, most of them trained on the spot.

Visceral leishmaniasis is caused by the protozoal parasite *Leishmania donovani*. Clinical features include fever, abdominal pain, weight loss, hepatosplenomegaly, diarrhoea, cough and epistaxis. Complications include severe malnutrition and Post-Kala-Azar Dermal Leishmaniasis. The average
incubation period is 2–4 months. Mortality of untreated, clinical Kala Azar is thought to be very high. Textbooks quote figures of 80–90%, but primary sources are lacking. A survey in Western Upper Nile estimated the mortality associated with infection to be at least 69%, making it a safe assumption that mortality due to clinical Kala Azar is even higher and likely to be over 90%. Diagnosis of VL is confirmed by a direct agglutination test (DAT), supplemented by microscopic examination of spleen aspirates for borderline cases and as a test of cure (TOC) at the end of treatment. The recommended treatment is a pentavalent antimonium salt. In this programme Pentostam (Sodium Stibogluconate, SSG) was used as first line treatment, which needs to be continued for 30 days and on average costs about US$ 100 per patient. The treatment proved highly effective, with cure rates between 80% and 90% (test of cure negative after 30 days). Only 3% either had a positive TOC at the end of the 30 day treatment and/or were found to have relapsed within the study period. Once cured, there is no remaining disability. Five per cent of VL patients in Africa develop transient, but occasionally relatively serious skin lesions, Post-Kala-Azar Dermal Leishmaniasis (PKDL). In general, PKDL patients respond well to prolonged treatment with SSG.

Survey data indicated that the epidemic had actually started in 1984, and that an estimated 38–57% of the total population died between 1984 and 1994. In absolute figures, around 100,000 people have probably died from VL in Western Upper Nile in this period. The MSF programme treated 18,948 VL patients between 1989 and 1995.

Methods

Outcome measures

Information about the impact of the VL treatment programme is available for 3067 patients during the period from August 1990 to July 1991 (Table 1). For the purpose of this cost-effectiveness analysis we have assumed that the proportions of treated patients by age who died, got cured (TOC negative after 30 days), defaulted and with positive TOC after 30 days and/or relapse, remained the same during the whole period between 1990 and 1994.

Cost information is available by calendar year while information on numbers of patients treated is only reported by transmission season (from August to July). Therefore, we estimated the total number of patients treated between 1990 and 1994 by including half of the patients treated in the ‘89–’90 and ‘94–’95 transmission seasons.

We further assumed that without treatment case fatality is 75% in children and 90% in adults. The proportion of lives saved by the programme is then the difference between the treated and untreated case fatality (Table 2). Although only a few of the patients with a positive TOC, a relapse and/or defaulters were known to have died, in the analysis we have assumed that all died. This would have the effect of overestimating the true cost-effectiveness ratio.

Because long-term disability is an infrequent outcome of VL, we considered only the Years of Life Lost (YLL) due to premature mortality in the calculation of DALYs. For the sake of comparing the cost-effectiveness ratio of this VL programme with international estimates of the cost-effectiveness of other health interventions, we present discounted and age-weighted YLL as described by Murray, using Coale and Demeny’s West level 26 model life table as a reference.

Costs

The costs of the VL programme in Western Upper Nile are derived from the MSF Holland annual financial reports of the Southern Sudan programmes and the co-ordination office in Nairobi. The reports only specify general budget lines and the totals for the whole programme in Western Upper Nile as shown in Table 2, column 1.

Table 1. Outcomes of the VL treatment programme, Western Upper Nile, August 1990 to July 1991

<table>
<thead>
<tr>
<th>Age group</th>
<th>total patients n</th>
<th>TOC negative n (%)</th>
<th>died n (%)</th>
<th>defaulted n (%)</th>
<th>TOC positive and/or relapse n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>290</td>
<td>200 (69)</td>
<td>58 (20)</td>
<td>19 (7)</td>
<td>13 (6)</td>
</tr>
<tr>
<td>5–14</td>
<td>1178</td>
<td>1044 (89)</td>
<td>77 (7)</td>
<td>29 (3)</td>
<td>28 (3)</td>
</tr>
<tr>
<td>15–24</td>
<td>707</td>
<td>602 (85)</td>
<td>62 (9)</td>
<td>27 (4)</td>
<td>16 (3)</td>
</tr>
<tr>
<td>25–34</td>
<td>460</td>
<td>388 (84)</td>
<td>52 (11)</td>
<td>13 (3)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>35–44</td>
<td>235</td>
<td>185 (79)</td>
<td>35 (15)</td>
<td>6 (3)</td>
<td>9 (5)</td>
</tr>
<tr>
<td>45+</td>
<td>197</td>
<td>137 (70)</td>
<td>50 (25)</td>
<td>5 (3)</td>
<td>5 (4)</td>
</tr>
<tr>
<td>Total</td>
<td>3067</td>
<td>2556 (83)</td>
<td>334 (11)</td>
<td>99 (3)</td>
<td>78 (3)</td>
</tr>
</tbody>
</table>

NB: 77 out of the 78 patients in the TOC positive and/or relapse group were cured after continued treatment with SSG or after second line treatment.

One relapse and 8 defaulters died during second or continued admission; they are not included in 334 who died during first admission.

Relapses only include those patients who came back with complaints by themselves.
incurred for the VL programme in Western Upper Nile, 1990–1994

Table 2. Total costs of the MSF programme and estimated cost incurred for the VL programme in Western Upper Nile, 1990–1994

<table>
<thead>
<tr>
<th></th>
<th>Total costs US$</th>
<th>High estimate of costs for VL US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expatriate staff, VL programme</td>
<td>894 784</td>
<td>894 784</td>
</tr>
<tr>
<td>Expatriate staff, other health programmes</td>
<td>669 993</td>
<td>–</td>
</tr>
<tr>
<td>Office</td>
<td>358 470</td>
<td>268 853</td>
</tr>
<tr>
<td>Transport</td>
<td>1 401 804</td>
<td>1 051 353</td>
</tr>
<tr>
<td>Communication</td>
<td>134 689</td>
<td>101 016</td>
</tr>
<tr>
<td>Local staff</td>
<td>119 468</td>
<td>89 601</td>
</tr>
<tr>
<td>Drugs VL (SSG)</td>
<td>1 616 472</td>
<td>1 616 472</td>
</tr>
<tr>
<td>Other drugs</td>
<td>2 602 126</td>
<td>1 951 595</td>
</tr>
<tr>
<td>Office Nairobi</td>
<td>496 347</td>
<td>372 260</td>
</tr>
<tr>
<td>Other</td>
<td>510 854</td>
<td>383 141</td>
</tr>
<tr>
<td>Total</td>
<td>8 135 015</td>
<td>6 729 075</td>
</tr>
</tbody>
</table>

The costs of the co-ordination office in Nairobi were extrapolated from the 1990 report, when the programme in Western Upper Nile was the only one supported by the office. In the years following, it was impossible to distinguish between the costs incurred for Western Upper Nile and other programmes that were implemented later on. This will give a slight over-estimation of the fixed costs as it is likely that the Nairobi office costs related to the VL programme decreased when the office was also used for other programmes.

Costs for local staff were very low. The majority of staff working in the health programme did not receive a salary but only food rations from the Sudan Relief and Rehabilitation Association and incentives in kind, like oil, salt and soap, from MSF. The hospital building in Ler required only some basic maintenance, and the absence of a generator and running water kept the running costs of VL inpatient facilities low. When admission capacity had to be expanded, small traditional huts were built by the community to accommodate the influx of VL patients. Building maintenance and construction are included under ‘other’. Inpatients were required to bring their own food.

It was also difficult to disentangle the costs attributable to the VL programme from the overall costs of the hospital and health posts, with the exception of expatriate staff costs and the cost of SSG. The cost of SSG was estimated by multiplying the total number of patients treated with the average drug cost per patient (6.7 ml of SSG per patient per day for 30 days), adding a 10% wastage factor. For the other budget lines in Table 2, we made a high, 75%, estimation of the costs attributable to the VL programme (column 2). Total drug costs were taken as variable costs to calculate marginal costs.

Uncertainty analysis

We examined the impact of uncertainty of the estimates of outcomes and costs through simulation, a method recommended by a US Public Health Service consensus panel on appropriate methods for standardizing the conduct of cost-effectiveness analyses for use in policy arenas.19 We used the @RISK software (distributed by Palisade corporation, Newfield, NY) which allows uncertainty distributions of health outcome and cost variables to be entered in a spreadsheet instead of single estimates. The computer then generates the distribution of possible cost-effectiveness ratios by recalculating the spreadsheet over and over again, each time using different randomly selected sets of values from the probability distributions of the input variables. We entered ‘uniform’ uncertainty distributions for the untreated case fatality rates (60–75% in children and 70–90% in adults), the proportion of defaulters and relapses who died (25–75%) and the distribution of costs to the VL programme (50–75%). We also modelled a range of life expectancies that are more appropriate for the Sudan, using a uniform distribution with model life table South level 8 as the lower limit (indicating a life expectancy at birth of 34 years in men) and level 12 as the upper limit (corresponding with a life expectancy at birth of 47.5 years in men).

Results

At least 66% of 17 101 patients treated for VL are estimated to have survived due to treatment (Table 3), accounting for 366 416 DALYs averted.

The average cost per patient treated was US$ 394 and the marginal cost US$ 209. The point estimates are derived from a scenario with high cost estimates, high case fatality, an unlikely total mortality among all defaulters and relapses, and the high life-expectancy standard used in the Global Burden of Disease study. Modelling the uncertainty about the first three of these parameters shows that the average and marginal cost-effectiveness ratios may have been underestimated or overestimated by one third to one half. Substitution of a more realistic local life-expectancy estimate causes only a minor change in the cost-effectiveness ratios (Table 4).

Discussion

With the given figures and assumptions, we arrive at a cost of US$ 18.40 per DALY averted. This places the treatment of VL in Western Upper Nile among the most cost-effective health interventions at less than US$ 25 per DALY averted. Similar to treatment of TB (US$ 3 per DALY), acute respiratory tract infection (US$ 20–50 per DALY) and immunization against DPT, polio and measles (<US$ 25 per DALY).20 This indicates that the intervention provided ‘very good value for money’. The uncertainty about costs and impact of the programme does not alter this conclusion. Despite the relatively high cost of treatment for each individual, the cost-effectiveness is very favourable due to the high effectiveness of treatment.

Of course, this only applies under the given, local conditions and care should be taken in generalizing this conclusion. Furthermore, the high number of patients influences the cost-effectiveness ratios (economy of scale). However, it is unlikely that the cost-effectiveness ratios would change drastically if
less patients had received treatment. Major contributing costs like the SSG, other drugs and expatriate staff would decrease as numbers of patients decrease.

While the programme was running, we were not aware of the possibility of such cost-effectiveness calculations. Potentially we could have made them, all required information being available. Would it have made a difference to the internal management of the programme, in its funding or in priority setting?

Internal management

Restricted access to patients due to insecurity was always the main limiting factor in the programme. If access had been better and if we could have increased the coverage of the programme, the available financial means would have been further stretched or extra funding would have been required to treat the additional patients. That would have made it more urgent to consider costs and effects. For instance, trade-offs between cost-saving, by sending fewer expatriates, and loss of quality (impact) could have been quantified.

Funding

Médecins Sans Frontières spent substantial amounts of its ‘unrestricted’ private funds on this programme. The decision to do so was not based on cost-effectiveness arguments, but rather on decision-makers’ first-hand knowledge of the seriousness and the scale of the problem. Furthermore, the intervention itself, medical work in a war zone, fitted well within the mandate of the organization. However, additional external donor funding was essential, continuously looked for and, irregularly, received from a variety of donor agencies.

Donor disapproval was usually linked to the perceived low cost-effectiveness, based on the high cost per individual patient treated in a ‘vertical’ programme. In the mean time, the inclusion of the outcome of this analysis in recent proposals for the continuation of the VL programme to donors has been an important additional argument to obtain further funding.

Setting priorities

In addition to the relatively high cost of the drugs per patient treated, both donors and MSF staff expressed concerns about the exclusion of other possible health care interventions, such as EPI and TB-treatment, and also about ‘coverage’ – the treatment of a limited number of patients a year versus providing basic health services to the population at large.

A cost-effectiveness analysis, as presented here, would have been useful in this debate. The cost of VL treatment per

Table 3. Estimated impact of VL treatment programme, Western Upper Nile, 1990–1994

<table>
<thead>
<tr>
<th>Age group</th>
<th>Patients treated</th>
<th>Patients cured</th>
<th>Patients died</th>
<th>Patients defaulted/relapsed</th>
<th>Expected deaths in absence of treatment</th>
<th>Minimum estimate of lives saved*</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>1 617</td>
<td>1 115</td>
<td>323</td>
<td>178</td>
<td>1 213</td>
<td>711</td>
</tr>
<tr>
<td>5–14</td>
<td>6 568</td>
<td>5 821</td>
<td>429</td>
<td>318</td>
<td>4 926</td>
<td>4 179</td>
</tr>
<tr>
<td>15–24</td>
<td>3 942</td>
<td>3 357</td>
<td>346</td>
<td>240</td>
<td>3 548</td>
<td>2 962</td>
</tr>
<tr>
<td>25–34</td>
<td>2 565</td>
<td>2 163</td>
<td>290</td>
<td>111</td>
<td>2 308</td>
<td>1 907</td>
</tr>
<tr>
<td>35–44</td>
<td>1 310</td>
<td>1 032</td>
<td>195</td>
<td>83</td>
<td>1 179</td>
<td>900</td>
</tr>
<tr>
<td>45+</td>
<td>1 098</td>
<td>764</td>
<td>279</td>
<td>56</td>
<td>989</td>
<td>654</td>
</tr>
<tr>
<td>Total</td>
<td>17 101</td>
<td>14 252</td>
<td>1 862</td>
<td>987</td>
<td>14 163</td>
<td>11 314</td>
</tr>
<tr>
<td></td>
<td>(100%)</td>
<td>(83%)</td>
<td>(11%)</td>
<td>(6%)</td>
<td>(83%)</td>
<td>(66%)</td>
</tr>
</tbody>
</table>

* The minimum estimate of lives saved assumes that all who defaulted or relapsed died

Table 4. Point estimates and uncertainty ranges of the average and marginal cost-effectiveness ratios of the VL treatment programme, Western Upper Nile, 1990–1994

<table>
<thead>
<tr>
<th>Cost-effectiveness ratio</th>
<th>point estimate</th>
<th>uncertainty range</th>
<th>uncertainty range using local life expectancy estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>average cost per life saved</td>
<td>$595</td>
<td>$413.43–796.50</td>
<td>$217.66–433.57</td>
</tr>
<tr>
<td>marginal cost per life saved</td>
<td>$315</td>
<td>$18.40</td>
<td>$12.37–25.03</td>
</tr>
<tr>
<td>average cost per DALY averted</td>
<td>$9.20</td>
<td>$7.13–15.03</td>
<td>$13.53–27.63</td>
</tr>
<tr>
<td>marginal cost per DALY averted</td>
<td>$9.20</td>
<td>$7.13–15.03</td>
<td>$13.53–27.63</td>
</tr>
</tbody>
</table>
DALY averted is lower than ‘intuitively’ assumed, while extremely poor access in this area may make EPI, for instance, a much less cost-effective intervention than it usually is.

However, the high prevalence of VL in this area, causing havoc to the whole of local society, played an important role in giving priority to the VL treatment. CEA, as presented here, would not have taken that into account. Calculation of the (local) burden of disease, with the use of DALYs, would have helped, but would still not have captured the disruption of a highly prevalent, killing disease on society at large within the context of a chronic conflict.

The use of a new CEA-indicator, Disability Adjusted Life Years (DALYs), has recently entered the debate on effectiveness measures and priority setting for health planning. However, to date, it is not yet in the field of emergency health planning. Should it be used in this field as well?

Our VL case shows that it is possible to calculate the cost of an emergency health intervention, expressed in terms of cost per DALY averted. This provides us with a comparable measure of effectiveness for different health interventions related to costs. However, often, data will not be available or will be extremely difficult to gather. The CEA will be related to costs. However, often, data will not be available or will be extremely difficult to gather. And the CEA will be based on local circumstances, which can vary considerably within and between emergencies. In comparing interventions, it will be particularly difficult to compare specific disease-control activities with provision of basic health services, for which it is even more complex to collect proper data and to determine their effectiveness. Still, we feel that in evaluations of emergency interventions attempts could be made more often to perform CEA, including the use of DALYs, provided that the outcomes of these analyses are seen in the broad context of the emergency situation and its consequences on the affected population.

The development of CEA as a practical, well-applied tool to assist in priority setting during an emergency will take more work and reflection. This would need models in which local rapid-assessment data can be plugged in. The availability of an international data base of cost-effectiveness studies of health interventions during relief operations, that uses a comparable measure of health outcome such as the DALY, would assist these efforts. This paper provides a first contribution to such a database.

References


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Biographies

André Griekspoor has been working as the manager of the Monitoring and Evaluation Unit, Médecins Sans Frontières, Amsterdam, since April ’97. Previous positions included Health Advisor in the
Medical Department, MSF, for two and a half years, supporting projects in Bosnia, Albania and North and South Sudan. He has worked for MSF in South Sudan, Ethiopia, Rwanda and Liberia.

Egbert Sondorp, MD, MPH, is presently working as a freelance consultant. Currently he is undertaking an evaluation of the MSF cholera intervention in Uganda. From 1994 until February 1998, he was director of Health Net International. Prior to this, he was the manager of the Medical Department, Médecins Sans Frontières, Amsterdam, between 1988 and 1994. He has been attached as health advisor to the MSF visceral leishmaniasis programme since 1989.

Theo Vos, MD, MSc, is currently Senior Regional Epidemiologist at the Department of Human Services in the state of Victoria, Australia. He is undertaking a burden of disease study in Victoria and developing a computer-assisted telephone interview health survey. The work presented in this paper was carried out while he was a lecturer at the Maternal and Child Epidemiology Unit, London School of Hygiene and Tropical Medicine. Previously he worked for five years in Zimbabwe and three and a half years in Lesotho as a medical officer at district and provincial level.

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