

Cost Utility Analyses in International Disaster Responses—Where Are They?

Richard Zoraster, MD, MPH

Office of Public Health Studies and
Department of Surgery, John A. Burns
School of Medicine, University of Hawaii,
Honolulu, Hawaii USA

Correspondence:

Richard Zoraster, MD, MPH
Office of Public Health Studies and
Department of Surgery
John A. Burns School of Medicine
University of Hawaii
651 Ilalo Street, MEB
Honolulu, HI 96813 USA
E-mail: rzoraster@yahoo.com

Keywords: Cost Utility Analysis; CUA;
DALY; Disability Adjusted Life Years; health
metrics

Abbreviations:

CEA: Cost Effective Analysis
CUA: Cost Utility Analysis
DALY: Disability Adjusted Life Year
GDP: Gross Domestic Product
HDRP: Health Disaster Response Programs
US: United States
WHO: World Health Organization
YLL: Years of Life Lost
YLD: Years Lived with Disability

Received: November 27, 2011

Accepted: January 22, 2012

Revised: January 24, 2012

Online publication: May 17, 2012

doi:10.1017/S1049023X12000477

Abstract:

International health care providers have flocked to Haiti and other disaster-affected countries in record numbers. Anecdotal articles often give “body counts” to describe what was accomplished, followed months later by articles suggesting outcomes could have been better. Mention will be made that various interventions were “expensive,” or not the best use of limited funds. But there is very little science to post-intervention evaluations, especially with regard to the value for the money spent. This is surprising, because a large body of literature exists with regard to the Cost Utility Analysis (CUA) of health care interventions. Applying reproducible metrics to disaster interventions will help improve performance.

This study will: (1) introduce and explain basic CUA; (2) review why the application of CUA is difficult in disaster settings; (3) consider how disasters may be unique with regard to CUA; (4) demonstrate past and theoretical utilization of CUA in disaster settings; and (5) suggest future utilization of CUA by healthcare providers in Disaster Response.

Zoraster R. Cost utility analyses in international disaster responses—where are they?
Prehosp Disaster Med. 2012;27(2):198-203.

Introduction

International Health Disaster Response Programs (HDRP) such as foreign medical teams and field hospitals are presumed to be expensive.¹⁻⁵ The evidence supporting this assumption is limited—are these interventions being compared to non-disaster interventions or to each other? What is the appropriate health metric in disasters, and should the costs of these interventions be measured? If it is possible to measure costs and outcomes, why isn't this measurement undertaken?

There is a growing demand that international health programs be both effective and provide good value for the money.⁶⁻¹¹ Major international donors such as the World Bank, Asian Development Bank, the Global Alliance for Vaccines and Immunizations, the Organization for Economic Cooperation and Development, and the Gates Foundation, along with World Health Organization (WHO), academic groups and non-government consortiums, have generated documents, metrics, new departments, and coalitions in an attempt to improve both the effectiveness and the efficiency of health aid.^{12,13} Measuring health outcomes with metrics in some form of cost utility analysis (CUA), such as cost-effectiveness analysis (CEA), has become an increasingly important component in the assessment of health interventions.¹⁴⁻¹⁶

For health-oriented disaster programs, it would seem relatively easy to collect data on cost and impact. After all, these are often unique programs that require funding, and tracking outcomes is a common medical practice. The short duration might be expected to make it easier to track funding and outcomes than for programs with long timelines.

The relative paucity of literature concerning costs, outcomes, and “economic health metrics” of HDRP may have many reasons. These vary from the difficulty in collecting and analyzing the data, institutional issues for aid organizations, ethical issues regarding CUA in general, and, most importantly, whether disasters have unique aspects that may make CUA either inappropriate or impossible to assess.

This last issue is critically important if donors become more obsessed with utilizing CUA for funding. This study will review the concepts of CUA as they relate to HDRP, consider the specific difficulties applicable to performing CUAs in disaster situations (Table 1), and discuss the relevance of CUA to HDRP. Finally, this study will utilize previously published articles that have performed a CUA for HDRP, or given enough

1. Data acquisition and calculations
a. Selecting appropriate metrics
b. Tracking data
c. Methodology
2. Institution issues
a. Impact on donor funding
b. Impact on future programs
c. Acceptance of transparency
d. Direct health is only one part of response
3. Ethical utilization of Cost Utility Analysis
a. Putting monetary value on life
b. Relevance of international values on local communities

Zoraster © 2012 Prehospital and Disaster Medicine

Table 1. Difficulties applicable to performing CUAs in disaster situations

information to prove that it is possible to make these calculations. Consideration will be made as to the future role for CUA for disaster response.

Report and Discussion

Definitions

An appropriate starting point for this analysis is to be clear on the utilization of terms. Most all health metrics utilize a fraction; the numerator is the cost of an intervention and the denominator is some measure of benefit to the recipient population.^{17,18} The most common health metric is Cost Effective Analysis (CEA), which, for developing nations and injury in general, is usually expressed as United States Dollars (US \$) per Disability Adjusted Life Year (DALY).^{19–21} The DALY is the sum of Years of Life Lost (YLL) plus Years Lived with Disability (YLD). YLL are calculated as life expectancy (either ideal or a regional/local) minus the age at death. YLD are also calculated in the same manner, but are adjusted for a Disability Weighting, expressed on a 0 to 1 scale, with 1 being a year spent in perfect health.^{20–23} With discounting, but uniform age weighting, a newborn's potential YLL is approximately 30, a 30-year-old's is 26, and a 60-year-old's is approximately 17.²⁴

The methodology is extensively documented elsewhere.^{22,25,26} In brief, various states of health were ranked relative to each other in multiple focus groups, to develop a presumed preference of health states. As an example, a foot or leg amputation has a DALY of 0.300, but a finger is 0.102.²⁷

Hundreds, if not thousands, of studies have been performed using CUA to assess public health interventions, many of them in the international setting. Immunization programs often appear to be the most economical, with programs claiming numbers around under US \$10/DALY.^{28,29} At the other end of the spectrum, open heart surgery in the United States is greater than US \$5,000/DALY.²⁹ While there are many criticisms of the methodology and assumptions of this approach, the DALY remains the dominant health metric for CEA in the developing world, and commonly is used to compare various interventions.

Cost-Effective Data Collection and Analysis in Disaster Response Studies of CUA often have methodological problems.^{30–37} One difficulty is generating the appropriate total for costs in the numerator. Guidelines have been published, discussing such relevant issues as start-up costs, allocation of program costs, and the utilization of expatriate staff.^{34,38,39} This last issue is very significant for disaster programs that utilize expatriate staff; their cost should be calculated at the actual cost. If they are volunteers, then the cost is considered to be zero.³⁴ “Opportunity costs” of their lost wages have typically not been included in calculations.

Calculation of the denominator, the DALY (YLL plus YLD) also may be difficult. One problem is the number of assumptions required to generate the constants for the formula. These include how to value money over a life expectancy (discounting), what is an appropriate life expectancy, and what is the relative value of life at different ages (“age-weighting”). All of these assumptions lead to an onerous-looking mathematical formula (Figure 1).²³ Fortunately, the formula may be reduced to a calculation for Excel spreadsheets (Microsoft Corporation, Redmond, Washington USA).²²

Attempts have been made to standardize the assumptions required for the CEA calculations,¹⁷ but, acknowledging that there continue to be differences in assumptions used, prominent peer-reviewed medical journals generally have asked that authors document the assumptions made, rather than dictating which to use.³¹ Most articles appear to agree on the use of discounting cost over time at a 3% rate, and most seem to discount life-years in the same manner. But there is variation in the use of age weighting between the original concept of non-uniform age weighting, and of uniform age weighting; the former places slightly higher value on the years lived at the middle portion of life.²⁴ The more recent WHO recommendations are to use uniform age weighting, but with discounting (Table 2).³⁹

Another controversial point is what potential life span is to be utilized.^{40–42} The original studies chose an optimal life span of 82.5 years for women and 80 years for men, but these numbers may not be realistic for impoverished communities. Accordingly, there are now regional numbers that may be used.⁴⁰ As discussed above, as long as the assumptions used are documented, data can be considered with or without discounting and/or age-weighting.

Directly relevant to a disaster response is the need to have sufficient outcome information to make the calculations. Without outcome information, one cannot compare the intervention to the “null” or “counterfactual,” i.e., if the intervention had not occurred at all. While it may be tempting to think that disaster care is of a certain benefit, many times there is an over-supply of providers, and sometimes it appears that the organized intervention made little or no impact.^{2,4}

An example would be the incremental value of an additional field hospital following the Bam Earthquake.⁴ If the assumption is made that the response was the only resource for an intervention, especially for traumatic injuries, the outcome calculation and subsequent YLL and YLD calculations should be straightforward, and any limitation would be due to poor data collection and a lack of planning. If a program is so shortsighted that outcomes cannot be followed, perhaps the intervention itself should be questioned.^{43–45}

Institutional Issues for Aid Organizations

While the concept of providing beneficial care to the recipients in an efficient manner is commonly accepted, presenting actual numbers creates the potential for ranking programs based on efficiency. In turn, this may make less “efficient” programs less likely

$$DALYs[r, K] = D \left\{ \frac{KCe^{ra}}{(r+\beta)^2} [e^{-(r+\beta)(L+a)} [-(r + \beta)(L + a) - 1] - e^{-r+\beta a} - r+\beta a - 1] + 1 - Kr1 - e^{-rL} \right.$$

Where:
 DALYs = Disability Adjusted Life Years
 r = discount rate (e.g., 3% corresponds to a discount rate of 0.03)
 K = age weighting modulation constant, either 1 or 0
 D = Disability weight (ranges from 0 for perfect health to 1 for death)
 C = adjustment constant for age-weights
 a = current age at onset of disability or death
 L = Duration of disability condition or life expectancy in case of death
 β = age weighting constant

From: Murray CJL, Acharya AK. Understanding DALYs. *J Health Econ.* 1997;16:703-730.

Zoraster © 2012 Prehospital and Disaster Medicine

Figure 1. Formula for calculation of DALYs

Age & YLLs Lost	Non-Uniform	Uniform
0	30	33
30	29	36
60	17	12
90	4	1

Zoraster © 2012 Prehospital and Disaster Medicine

Table 2. Uniform and non-uniform age weighting^a
^aAdapted from Mathers et al,²⁴ with 3% discounting

to be funded, creating a competitive environment. This may not be in the global interests of the aid agencies or the beneficiaries.⁴⁶

Organizations may also be concerned about the vast number of assumptions that go into the calculations, and the great variety in incurred costs calculation methods, which can differ according to time, place, and accounting procedures. CUA is difficult within a single organization, and likely inaccurate if used to compare among organizations and activities. The pursuit of effectiveness also has been criticized as discouraging innovation among aid organizations.⁹ The difficulties in accounting are not unique to disaster response, and it is generally accepted that small variations in cost/DALY probably do not mean much. However, when the costs/DALY differ by a power of 10 or 100, they are much more likely to be meaningful.²⁹

Disaster needs assessments are extremely difficult to complete for the initial response, and are usually based on limited knowledge. Accordingly, it would seem punitive that well-meaning interventions cause an organization to be labeled as “inefficient” if adequate productivity could not be calculated. Other have stated that the efforts expended in generating budgeting and compliance calculations are not justified by the benefits.⁴⁷

Those organizations that rely on “technical experts,” or expatriate staff paid at home nation rates, will likely find this significantly impacts their CUA,⁴⁸ and may be even more resistant than those who utilize national staff. On the other hand, for foreign aid in general, this practice has been criticized,⁴⁸⁻⁵⁰ and poor performance in CUA may be an appropriate criticism for HDRP.

1. Funding comes from different budgets
2. Variability and unpredictability of needs
3. Regional variation in DALY from published
4. Lack of valuation on short-term pain and suffering
5. Economic thresholds in a disaster

Zoraster © 2012 Prehospital and Disaster Medicine

Table 3. Unique issues in disasters

Additionally, the argument could be made that the outcomes measurable by DALYs are only one part of the value of HDRPs, and that the apparent efforts in the curative services may be significant in showing solidarity to the affected nation,⁵¹ with the potential to lead to quicker recovery. Multi-faceted international aid groups may view their disaster programs as entrées to future humanitarian programs, essentially “loss-leaders.” Another value that is not captured by health metrics is the potential value of teaching and examples. An International Urban Search and Rescue Team may not have saved many lives, but it may inspire an affected nation to develop its own local teams, which have a greater likelihood for future success.

Ethical Issues

Ethical arguments about the utilization of CEA in general are common,⁵²⁻⁵⁹ and, of direct relevance to HDRPs that often take on a very utilitarian approach,⁶⁰ there is a perspective that such a “utilitarian” or “Consequentialist” approach is inconsistent with humanitarian perspectives.^{51,60} However, if one accepts that most disaster response is based on utilitarian concepts of doing the greatest good for the greatest number,⁶¹ then this seems to be a weak argument against CUA.

Unique Aspects of Disasters

CUA typically has been used as a measure for interventions for a population. Most commonly, there is some specific health issue for which there is accumulated information about incidence and prevalence, and about the cost of intervention.

Additionally, estimations must be made about the potential utilization and outcomes of the intervention. This information allows an estimation of total cost, or changes in cost from prior interventions, that becomes part of a “sectoral” analysis for the health sector, and “informs” potential allocations of a fixed budget.^{16,17} This approach has aspects of a zero sum concept, i.e., funding for one project must come at the expense of another. However, if it is assumed that funds for each disaster are raised separately, and do not come from the overall moneys available for international health, this may be a significant reason not to compare disaster response funding to other potential international health programs.

Disasters may have some common issues, but vary in many unpredictable ways. The unique aspects of disasters lead to specific issues with calculation of CUA (Table 3). Early in a disaster, it is difficult to know what acute needs are, and what resources remain capable of providing them. This makes the counterfactual, not doing an intervention, very hard to calculate.

Additionally, there is only one set of global disability weights, but the significance of various disabilities is not comparable across cultures and societies.^{19,62-64} In an affluent society, one might become an amputee following a painless resection for vascular problems or a tumor; be given general anesthesia in the operating room and adequate post-operative pain medication, and receive a well-fitted prosthesis and disability payments from the government. Following an earthquake in a developing nation, one might lie in excruciating agony in rubble for several days, be dragged out by neighbors, receive an amputation with local anesthesia, have no post-operative pain medication, face a long wait for a poorly fitted prosthesis, and live in a hilly town with potholes. Both disabilities have a disability weighting of 0.300. It is far easier to be blind in New York or London than in the Sudan, but the DALY does not account for that.^{64,65}

While there are many ethical issues regarding CEA, one of particular relevance to disasters is the suggestion of thresholds, that is, the value at which an intervention is cost-effective.^{66,67} The Council on Macroeconomics has developed thresholds for “attractiveness” of interventions, ranging from “very cost-effective” for interventions that cost less than the Gross Domestic Product (GDP)/person to “cost-effective” for interventions costing less than three times the GDP/person.⁶⁷ Implicit in this is that interventions costing more than three times the GDP are not cost-effective. This would seem an extra burden for the poorest countries to bear, especially if a region has just had its local domestic product reduced to zero by a disaster.

Using Cost Utility Analysis for Health Disaster Response

Despite all of the above barriers, Gosselin, Gialamas, and Atkin demonstrated in 2011 that a CUA of an HDRP could be calculated when they reviewed a trauma response to the Haiti Earthquake.⁶⁸ Their calculations demonstrated a CEA of \$343/DALY averted.

For HDRPs, there are no other publications to compare the above numbers to, but there is data that can be utilized to

generate some approximations. One set of data comes from von Schreeb, who reviewed multiple field hospital deployments, with estimation that a field hospital daily bed cost is approximately US \$2,000 per day.² If one uses an approximation of 3.5 days as the average stay,⁶⁹ the cost per patient per occupied bed would be US \$7,000. If this saves the life of a young person, it would avert about 30 DALYs (discounted), or be valued at US \$233/DALY averted. This estimation will be affected by occupancy, and the true disability weightings of procedures occurred, and also by the counterfactual (if no field hospital equals no care). If occupancy is averaging 50%, a value of US \$466/DALY is calculated, and the typical patient is a leg amputation, the cost per DALY becomes over US \$1000. These numbers are very inexact, but they show a general range of hundreds of US \$ per DALY.

Another approximation could be generated using the data available from the Fairfax, Virginia USA Urban Search and Rescue Team in Haiti.⁷⁰ They recorded 15 rescues who survived, one of whom received an amputation. Assuming that their follow-up data is accurate, and that all would have died without their intervention, their efforts averted 383 DALYs. The costs are not entirely obvious; past United States Agency for International Development costs for an international USAR team have been approximately US \$2 million.⁷¹ Utilizing that number (and ignoring the costs of the French team which assisted on multiple rescues, and the cost of patient care following the rescues) generates a CEA of US \$5,221/DALY. This may represent either a relatively poor value, or be one of the situations where the international social and political significance of demonstrating solidarity, assisting a transition to recovery, and potential education is worth the investment.

Conclusion

With all the above limitations, CUA of HDRPs can be performed, and doing so more often will add to the body of scientific knowledge. Costs that are reasonably close or even a multiple of two or three may not be very significant, but if the CUA of a program differs in magnitude from that of others by a power of 10, 100, or even 1000, that merits attention.

There are a vast number of reasons that CUA may be distasteful to the humanitarian community. Those who champion CUA never have claimed it was perfect, nor have they suggested that CUA be the sole determinant of any program; it is suggested that CUA be utilized to “inform.” Decisions may also depend on many other factors, including ethical, social, cultural, political and budgetary.^{17,18,72-74}

Despite the complexities of using CUA for disaster response, it is possible to perform the required calculations, and a common metric should not be rejected without further analysis and consideration. It may be that the Global Burden of Disease project is an inappropriate tool for disaster evaluation, and needs modification for disaster response, but the field of disaster research has not demonstrated that. Research in this area should expand to evaluate which health metrics to use, and how to use them.

References

1. Tsunami Evaluation Coalition. The roles of needs assessment in the Tsunami Response. ALNAP 2006. http://ochanet.unocha.org/p/Documents/TEC_Needs_Report.pdf. Updated July 2006. Accessed May 31, 2011.
2. Von Schreeb J, Riddez L, Samnegård H, Rosling H. Foreign field hospital in the recent sudden-onset disasters in Iran, Haiti, Indonesia, and Pakistan. *Prehosp Disaster Med.* 2008;23(2):144-151.
3. Pan American Health Organization. *WHO-PAHO Guidelines for the Use of Foreign Field Hospitals in the Aftermath of Sudden-Impact Disasters.* Washington, D.C.: Pan American Health Organization; 2003.
4. De Ville de Goyet C. Health lessons learned from the recent earthquakes and Tsunami in Asia. *Prehosp Disaster Med.* 2007;22(1):15-21.
5. VanRooyen MJ, Hansch S, Curtis D, Burnham G. Emerging issues and future needs in humanitarian assistance. *Prehosp Disaster Med.* 2001;16(4):216-222.
6. Murray CJL, Anderson B, Burstein R, et al. Development assistance for health: trends and prospects. *The Lancet.* 2011; DOI:10.1016/S0140-6736(10)62356-2.
7. World Health Organization. *CHOosing interventions that are Cost Effective (WHO CHOICE). An overview of the rationale, activities and goals of WHO-CHOICE.* <http://www.who.int/choice/description/benefits/en/>. Accessed June 2, 2011.

8. Banatvala N, Zwi A. Public health and humanitarian interventions: developing the evidence base. *BMJ*. 2000;321:101-105.
9. Harvey P, Stoddard A, Harmer A, Taylor G; ALNAP. The state of the humanitarian system: assessing performance and progress. <http://www.alnap.org/pool/files/alnap-sohs-final.pdf>. Updated January 2010. Accessed June 2, 2011.
10. Wikler D. Why prioritize when there isn't enough money? *Cost Effect Resource Alloc*. 2003;1:5. <http://www.resource-allocation.com/content/1/1/5> Published February 26, 2003. Accessed May 31, 2011.
11. Schieber GJ, Gottret P, Fleisher LK, Leive AA. Financing global health: mission unaccomplished. *Health Affairs*. 2007;26(4):921-934.
12. Organization for Economic Co-operation and Development. Paris declaration on aid effectiveness. http://www.oecd.org/document/22/0,3746,en_2649_3236398_36074966_1_1_1_1,00.html. Published 2005. Accessed May 31, 2011.
13. Institute for Health Metrics and Evaluation. Collaborators. <http://www.healthmetricsandevaluation.org/research/collaborators>. Accessed June 2, 2011.
14. King CH, Bertino A. Asymmetries of poverty: why global burden of diseases valuations underestimate the burden of neglected tropical disease. *PLoS Negl Trop Dis*. 2008;2(3):e209.
15. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL. Measuring the global burden of disease and risk factors, 1990-2001. In: Lopez AD, Mathers CD, Ezzati M, et al, eds, *Global Burden of Disease and Risk Factors*. Washington (DC): World Bank; 2006.
16. Hutubessy R, Chisolm D, Edeger TT-T. WHO Choice. Generalized cost-effectiveness analysis for national-level priority-setting in the health sector. *Cost Eff Resour Alloc*. 2003;1(1):8 <http://resource-allocation.com/content/1/1/8> Accessed May 13, 2011.
17. Baltussen R, Adam T, Tan-Torres Edejer T, et al. Part One: Methods for generalized cost-effectiveness analysis. What is generalized cost-effectiveness analysis?. In: Tan-Torres Edejer T, Bltussen R, Adam T, et al, *WHO Guide to Cost-Effectiveness Analysis*. Geneva: World Health Organization; 2003.
18. Murray CJL, Evans DB, Acharya A, Baltussen R. Development of WHO guidelines on generalized cost-effectiveness analysis. *Health Econ*. 2000;9:235-251.
19. James KC, Foster SD. Weighting-up disability. *Lancet*. 1999;354(9173):87-88.
20. Jamison DT, Breman JG, Measham AR, et al. *EDs Priorities in Health*. Washington, DC: The World Bank; 2006.
21. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL. Measuring the global burden of disease and risk factors, 1990-2001. In: Lopez AD, Mathers CD, Ezzati M, et al, eds, *Global Burden of Disease and Risk Factors*. Washington, DC: World Bank; 2006.
22. Fox-Rushby JA, Hanson K. Calculating and presenting disability adjusted life years (DALYs) in cost-effectiveness analysis. *Health Policy Plan*. 2001;16(3):326-331.
23. Murray CJL, Acharya AK. Understanding DALYs. *J Health Econ*. 1997;16(6):703-730.
24. Mathers CD, Salomon JA, Ezzati M, Begg S, Lopez AD. Sensitivity and uncertainty analyses for burden of disease and risk factor estimate. In: Lopez AD, Mathers CD, Ezzati M, et al, eds, *Global Burden of Disease and Risk Factors*. Washington, DC: World Bank; 2006.
25. Mathers CD, Vos T, Lopez AD, Salomon J, Ezzati M, eds. *National Burden of Disease Studies: A Practical Guide*. Edition 20. Global Program on Evidence for Health Policy. Geneva: World Health Organization; 2001.
26. Murray CJ, Lopez A. *The global burden of disease: A comprehensive assessment of mortality and disability from disease, injuries, and risk factors in 1990 and projected to 2020*. Cambridge: Harvard University Press; 1996.
27. Mathers CD, Bernand D, Iburg M, et al. *Global burden of diseases in 2002: data sources, methods and results*. GPE discussion paper no. 54. Geneva: World Health Organization; 2003.
28. Bradt DA. *Evidence-based decision-making in humanitarian assistance*. Humanitarian Practice Network. London: Overseas Development Institute; 2009.
29. Disease Control Priorities Project. *Priorities in Health*. Washington, DC: The World Bank; 2006. <http://www.dcp2.org/pubs/PIH>. Accessed June 2, 2011.
30. Drummond M, Sculpher M. Common methodological flaws in economic evaluation. *Med Care*. 2005;43:II-5-II-14.
31. Jefferson T, Demicheli V. Quality of economic evaluations in health care. *BMJ*. 2002;324:313-314.
32. Jefferson T, Smith R, Yee Y, Drummond M, Pratt M, Gale R. Evaluating the BMJ guidelines for economic submissions. *JAMA*. 1998;280:275-277.
33. Johns B, Baltussen R, Hutubessy R. Programme costs in the economic evaluation of health interventions. *Cost Effect Res All*. 2003;1:1. <http://www.resource-allocation.com/content/1/1/1>. Accessed May 5, 2011.
34. Drummond MF, Jefferson TO. for the BMJ Working Party on Guidelines for Authors and Peer-Reviewers of Economic Submissions to the British Medical Journal. Guidelines for authors and peer-reviewers of economic submissions to the British Medical Journal. *BMJ*. 1996;313:275-383.
35. Mulligan J, Walker D, Fox-Rushby J. Economic evaluations of non-communicable disease interventions in developing countries: a critical review of the evidence base. *Cost Effect Res All*. 2006;4:7.
36. Udvarheiyi IS, Colditz GA, Rai A, Epstein AM. Cost-effectiveness and cost-benefit analyses in the medical literature. Are they being used correctly? *Ann Intern Med*. 1992;116:238-244.
37. Neumann PJ, Zinner DE, Wright JC. Are methods for estimating QALYs in cost-effectiveness analyses improving? *Med Decis Making*. 1997;17:402-408.
38. Evans DB, Edejer TT, Adam T, Lim S. WHO choosing interventions that are Cost Effective (CHOICE) Millennium Development Goals Team. Methods to assess the costs and health effects of interventions for improving health in developing countries. *BMJ*. 2005;331:1137-1140.
39. Baltussen R, Adam T, Tan-Torres Edejer T, et al. Part One: Methods for generalized cost-effectiveness analysis. What is generalized cost-effectiveness analysis? (Reporting CEA Results). In: Tan-Torres Edejer T, Bltussen R, Adam T, et al, *WHO Guide to Cost-Effectiveness Analysis*. Geneva: World Health Organization; 2003.
40. Arnesen T, Kapiriri L. Can the value choices in DALYs influence global priority-setting? *Health Pol*. 2004;70:137-149.
41. Williams A. Calculating the global burden of disease: time for a strategic reappraisal? *Health Econ*. 1999;8:1-8.
42. Mathers CD, Murray CJL, Lopez AD, et al. *Estimates of Healthy Life Expectancy for 191 Countries in the Year 2000: Methods and Results*. GPE Discussion Paper No. 38. Geneva: WHO; 2000. <http://www.who.int/healthinfo/paper38.pdf>. Accessed April 18, 2012.
43. Hands up for Healthcare Workers. Org. Is Haiti's Health system any better? http://www.merlinusa.org/wp-content/uploads/2011/01/MerlinUSA_Is-Haiti-health-system-any-better.pdf. Merlin; 2011. Accessed June 2, 2011.
44. Chu K, Stokes C, Trelles M, Ford N. Improving effective surgical delivery in humanitarian disasters: lessons from Haiti. *PLoS Med*. 2011;8(4):e1001025 DOI:10.1371/journal.pmed.1001025.
45. Roy N, Shah H, Patel V, Coughlin RR. The Gujarat earthquake (2001) experience in a seismically unprepared area: community hospital medical response. *Prehosp Disaster Med*. 2002;17(4):186-195.
46. Proudlock K, Ramalingam B, Sandison P. Improving humanitarian impact assessment: bridging theory and practice. ALNAP 8th Review of Humanitarian Action. 2009. <http://www.alnap.org/pool/files/8rhach2.pdf>. Accessed June 3, 2011.
47. Natsios A. The clash of the counter-bureaucracy and development. Center for Global Development Essay. www.cgdev.org/content/publications/detail/1424271. Published 2010. Accessed June 2, 2011.
48. Gosselin RA, Maldonado A, Elder G. Comparative cost-effectiveness analysis of two MSF Surgical trauma centers. *World J Surg*. 2010;34:415-419.
49. Easterly W, Pfitze T. Where does the money go? Best and worst practices in foreign aid. *J Econ Persp*. 2008;22:29-52.
50. Herfkens E, Bains M. Reaching our development goals: why does aid effectiveness matter? <http://www.oecd.org/dataoecd/43/31/40987004.pdf>. Published 2009. Accessed April 18, 2012.
51. Robertson DW, Bedell R, Laveru JV, Upshur R. What kind of evidence do we need to justify humanitarian medical aid? *Lancet*. 2002;360:330-333.
52. Anand S, Hanson K. DALYs: Efficiency versus equity. *World Dev*. 1998;26:307-310.
53. Anand S, Hanson K. Disability-adjusted life years: a critical review. *J Health Econ*. 1997:685-702.
54. Arneson T, Nord E. The value of DALY life: problems with ethics and validity of disability adjusted life years. *BMJ*. 1999;319:423-425.
55. Tsuchiya A. QALYs and ageism: philosophical theories and age weighting. *Health Econ*. 2000;9:57-68.
56. Tsuchiya A. Age-related preferences and age-weighting health benefits. *Soc Sci Med*. 1999;48:267-276.
57. Williams A. QALYs and ethics: a health economists perspective. *Soc Sci Med*. 1996;43:1795-1804.
58. Cantor SB. Cost-effectiveness analysis, extended dominance, and ethics: a quantitative assessment. *Med Decis Making*. 1994;14:159-265.
59. Brock DW. Ethical issues in the use of cost-effectiveness analysis for prioritization of health care resources. In: Tan-Torres Edejer T, Bltussen R, Adam T, et al, *WHO Guide to Cost-Effectiveness*. Geneva: World Health Organization; 2003, p. 289-312.
60. James KC, Foster SD. Weighting-up disability. *Lancet*. 1999;354:87-88.
61. World Medical Association. *Statement on Medical Ethics in the Event of Disasters*. www.wma.net/en/30publications/10policies/d7/index.html. Published 14 October 2006. Accessed April 15, 2011.
62. Ustun TB, Rehm J, Chatterji S, et al. Multiple-informant ranking of disabling effects of different health conditions in 14 countries. WHO/NIH Joint Project, CAR Study Group. *Lancet*. 1999;354:111-115.
63. Robberstad B. QALYs vs DALYs vs Lys gained: what are the differences, and what difference do they make for health care priority setting? *Norsk Epidemiolog*. 2005;15(2):183-191.

64. Reidath DD, Allotey PA, Kouame A, Cummins RA. Measuring health in a vacuum: examining the disability weight of the DALY. *Health Pol Plan*. 2003;18(4):351-356.
65. Zou S. Applying DALYs to the burden of infectious diseases (letter). *Bull WHO*. 2001;79(3):267-268.
66. WHO Commission on Macroeconomics and Health. *Macroeconomics and Health: Investing in the Health for Economic Development*. Report of the Commission on Macroeconomics and Health. Geneva: World Health Organization; 2001.
67. Eichler HG, Kong SX, Gerth WC, Mavros P, Jonsson B. Use of cost-effectiveness analysis in health-care resource allocation decision-making: how are cost-effectiveness thresholds expected to emerge? *Value Health*. 2004;7:518-528.
68. Gosselin RA, Gialamas G, Atkin DM. Comparing the cost-effectiveness of short orthopedic missions in elective and relief situations in developing countries. *World J Surg*. 2011;35:951-955.
69. Fernald JP, Clawson EA. The Mobilie Army Surgical Hospital humanitarian mission in Pakistan: the primary care experience. *Mil Med*. 2007;172:471-477.
70. Macintyre A, Barbera JA, Petinaux BP. Survival internal in earthquake entrapments: research findings reinforced during the 2010 Haiti Earthquake response. *Disaster Med Public Health Preparedness*. 2011;5:13-22.
71. USAID Japan – Earthquake and Tsunami. Fact Sheet #13, Fiscal Year (FY) 2011. http://www.usaid.gov/our_work/humanitarian_assistance/disaster_assistance/countries/Japan/template/fs/fy2011/japan_eqtsu_fs13_03-24-2011.pdf. Published March 24, 2011. Accessed June 2, 2011.
72. Chapman RH, Berger M, Weinstein MC, Weeks JC, Goldie S, Neumann PJ. When does quality-adjusting life-years matter in cost-effectiveness analysis? *Health Econ*. 2004;13:429-436.
73. Laxminarayan R, Mills AJ, Breman JG, et al. Advancement of global health: key messages from the Disease Control Priorities Project. *Lancet*. 2006;367:1193-2008.
74. Shillcutt SD, Walker DG, Goodman CA, Mills AJ. Cost-effectiveness in low- and middle-income countries: a review of the debates surrounding decision rules. *Pharmacoeconomics*. 2009;27:902-917.