Vaccine 32 (2014) 5065–5070

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Valuing vaccines using value of statistical life measures

Ramanan Laxminarayan[a,b,*], Dean T. Jamison[c], Alan J. Krupnick[d], Ole F. Norheim[e]

[a] Center for Disease Dynamics, Economics & Policy, 1616 P Street NW, Suite 430, Washington, DC 20036, USA
[b] Princeton University, M43 Guyot Hall, Room 132, Princeton, NJ 08544, USA
[c] University of Washington, Department of Global Health, Ninth and Jefferson Building, 13th Floor, 908 Jefferson Street, Box 359931, Seattle, WA 98104, USA
[d] Resources for the Future, 1616 P Street NW, Suite 600, Washington, DC 20036, USA
[e] University of Bergen, Department of Medical Ethics, Department of Global Public Health and Primary Care, Kalfarveien 31, 5018 Bergen, Norway

ARTICLE INFO

Article history:
Received 11 November 2013
Received in revised form 19 June 2014
Accepted 8 July 2014
Available online 18 July 2014

Keywords:
Vaccine priorities
Vaccine policy
Willingness-to-pay measures
Value of statistical life

ABSTRACT

Vaccines are effective tools to improve human health, but resources to pursue all vaccine-related investments are lacking. Benefit–cost and cost-effectiveness analysis are the two major methodological approaches used to assess the impact, efficiency, and distributional consequences of disease interventions, including those related to vaccinations. Childhood vaccinations can have important non-health consequences for productivity and economic well-being through multiple channels, including school attendance, physical growth, and cognitive ability. Benefit–cost analysis would capture such non-health benefits; cost-effectiveness analysis does not. Standard cost-effectiveness analysis may grossly underestimate the benefits of vaccines.

A specific willingness-to-pay measure is based on the notion of the value of a statistical life (VSL), derived from trade-offs people are willing to make between fatality risk and wealth. Such methods have been used widely in the environmental and health literature to capture the broader economic benefits of improving health, but reservations remain about their acceptability. These reservations remain mainly because the methods may reflect ability to pay, and hence be discriminatory against the poor. However, willingness-to-pay methods can be made sensitive to income distribution by using appropriate income-sensitive distributional weights.

Here, we describe the pros and cons of these methods and how they compare against standard cost-effectiveness analysis using pure health metrics, such as quality-adjusted life years (QALYs) and disability-adjusted life years (DALYs), in the context of vaccine priorities. We conclude that if appropriately used, willingness-to-pay methods will not discriminate against the poor, and they can capture important non-health benefits such as financial risk protection, productivity gains, and economic wellbeing.

1. Introduction

Methodological approaches to setting priorities can be broadly divided into benefit–cost analysis (BCA) and cost-effectiveness analysis (CEA). Under BCA, the benefits and costs of a policy are expressed in monetary (dollar) terms. Subtracting the costs of the policy from the benefits gives the net benefit of the policy. Ideally, policies with the greatest net benefit should be the most preferred, all else being equal. BCA is also used to understand the distributional consequences of a policy for sex, race, and age groups. BCA offers comparability with similar analyses outside the health sector. In the context of vaccines, BCA includes non-health benefits like financial risk protection, future learning and productivity gains, which can be substantial, particularly for childhood vaccines.

Most non-economists in the health arena are familiar with cost-effectiveness analysis. Here, the metric is a simple ratio of the cost of an intervention and its health impacts (measured in deaths or disability-adjusted life years (DALYs) averted or quality-adjusted life years (QALYs) gained). In CEA, impacts are not expressed in monetary terms, and therefore it is not possible to conclude whether a policy increases social welfare, as is the case with BCA. CEA can help rank alternative interventions by order of cost-effectiveness. CEA analyses may be easier to conduct

* Corresponding author at: Center for Disease Dynamics, Economics & Policy, 1616 P Street NW, Suite 430, Washington, DC 20036, USA. Tel.: +1 202 328 5085; fax: +1 202 328 5170.
E-mail addresses: Ramanan@cddep.org, rlaxmina@princeton.edu (R. Laxminarayan), djamison@uw.edu (D.T. Jamison), krupnick@rff.org (A.J. Krupnick), Ole.Norheim@igs.uib.no (O.F. Norheim).

http://dx.doi.org/10.1016/j.vaccine.2014.07.003
0264-410X/

and communicate than BCA but may miss important non-health benefits of vaccines.

The fundamental divide between the two approaches is the following. Under BCA, health outcomes are judged by the extent of their contribution to overall societal wellbeing, measured as the sum of wellbeing of individuals. Under CEA, the objective is to maximize contributions to societal health, measured as the sum of individual health status. CEA approaches do not recognize the benefits of health care in broader welfare terms, or in terms of preferences for health relative to other goods [1,2].

What does this mean in practice? Under BCA, it may be preferable to provide treatment to a person who copes poorly with a disease, or who are thrown into poverty by it, rather than to someone who copes well. This makes sense because, in the latter case, individual wellbeing is not enhanced to as great an extent. In the CEA framework, the value of treatment for the two individuals would be independent of individual preferences, or their wellbeing, under the assumption that all individuals value similar health states similarly [3]. Most importantly, BCA accounts for many kinds of benefits, including non-health benefits and financial risk protection afforded by the intervention. It is in the valuation of health benefits in economic terms that value of a statistical life enters the picture.

2. Value of statistical life[1]

Although many think the value of a life is infinite, we all make decisions that implicitly place a value on our loss of limb and even life. The simplest example is the decision to cross a busy street against the light. One might get to his or her destination a bit faster—or one might not get there at all. We make a trade-off between the gain (shorter time to the destination) and the loss (small probability of loss of life or limb). Even a policymaker who allocates resources for health needs, based on his or her perception of costs and benefits, is implicitly and inescapably placing a value on life.

Three principal approaches are used to evaluate the value of a statistical life (VSL) and willingness to pay (WTP) for reducing risks to life. The most common approach is based on wage-risk trade-offs—the risk premiums paid to workers who accept jobs with a high risk of death or injury[2]. This approach is also called "revealed-preference" because it is based on an examination of how individuals actually behave in the face of job market risks[3]. Revealed preference uses labor market data to estimate the effect of morbidity and mortality risk on wage differences between occupations with differing levels of risk, after controlling for other variables that would explain wages[4]. For example, all else being equal, a construction worker employed on a high-rise building must be paid more than someone working on a single-story building to compensate him for the greater probability of dying on the job. VSLs are based on the fairly robust theory of compensating differentials—the idea that workers must be paid more to take on tasks that are unpleasant or hazardous[5]. At the same time, critics point out that while the observed risk premium is based on perceived risks, the calculation is almost always based on actual risks, because the former is unobserved. If these are different, bias will be introduced.

A second approach is based on observing how much consumers are willing to pay to lower the risk of death. A growing literature on VSLs has measured these values based on the risk-payoff trade-off and includes studies on the wages of Sherpas in the Himalayas (the value of climbers' safety being observable in higher wages for better guides) [4] and the willingness of U.S. states to forgo federal highway construction funds in exchange for higher speed limits [5]. Since VSLs estimated using these two approaches look at how people actually behave, economists see them as relatively complete measures of the economic value of health.

Whereas the two approaches described above are based on actual behavior, a third approach, "stated-preference", relies on survey responses to carefully structured, hypothetical questions about one's willingness to pay for a lower risk of death or disability. A challenge with "stated-preference" is that individuals may find it hard to provide accurate responses to direct willingness-to-pay questions, especially for unfamiliar options and small changes in risks [6]—but methods have improved substantially over the years, such as validity tests, which are built into the experimental design.

Stated-preference studies can obtain VSLs in specific contexts where revealed-preference approaches may not be applicable. For example, stated preference has been shown useful for determining the willingness-to-pay for a hypothetical malaria vaccine in Ethiopia [7]. Sometimes a vaccine introduction could involve trade-offs between different vaccines that vary in health benefits and target populations. Whereas a separate willingness-to-pay study may be needed for each health effect, a newer approach, called conjoint analysis, asks individuals to choose among different attributes, such as health states, to estimate "prices" for a variety of health attributes. Trade-offs made by study participants are then used to statistically estimate the relative importance of different health attributes. These kinds of studies, if conducted carefully, have the ability to complement VSL studies.

Recent World Health Organization (WHO) economic analysis guidelines on hypothetical estimates of willingness-to-pay recommend that, "(empirically-based) estimates of market losses be separately identified and reported from (hypothetically-based) estimates of foregone welfare[6]." These guidelines also rely on the cost-of-illness approach that tries to measure the cost associated with ill health and seeking treatment, but leaves out the costs of pain and suffering associated with illness and is, therefore, inconsistent with the welfare economic approach.

3. Use of VSL in health and other sectors

In the United States, the Office of Management and Budget requires that all federal agencies conduct both CEA and BCA on proposed rules and regulations whose annual effect on the economy will exceed $100 million. Recent updates to the guidelines require a CEA for major regulations where a significant emphasis is on health and safety, and BCA is required for major health and safety rulemakings to the extent that the primary health and safety outcomes can be expressed in monetary terms. The rationale underlying this

---

[1] The UK Green Book refers to the VSL measure as the value of a prevented fatality or prevented injury, which may be more easily understood than the notion of "statisticallives".

[2] Therefore, if lifetime wages for a high-rise construction worker with a 1/10,000 greater probability of death on the job are $500 more than for workers with a similar job but with a lower risk of death, VSL is calculated as $5,000,000.

[3] In contrast, in stated-preference methods respondents are asked how much they would hypothetically pay for a lower risk of death.

[4] For conceptual and implementation-related critiques of VSL; see [28].

[5] Even drug dealers understand compensating differentials. For instance, Steve asked a gang foot soldier who is normally was paid very little why he was paid 70% more during a gang war. "Would you stand around here when all this s— {shooting} is going on? No, right? So if I gonna be asked to put my life on the line, then front me the cash, man. Pay me more 'cause it ain't worth my time to be here when {the gangs are} warring."[29].

[6] WHO Guide to Identifying the Economic Consequences of Disease and Injury, World Health Organization, Department of Health Systems Financing Health Systems and Services http://www.who.int/choice/publications/d_economic_impact_guide.pdf.