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VIEWPOINTS ARTICLE

Economic Considerations in Infectious Diseases Emergency Response Preparedness: It's All About the Point of View

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Outbreaks and emergence of novel pathogens present a challenge in economic evaluations of prevention strategies, due to unusually high levels of risk aversion and uncertainty. Here, we discuss cost-effectiveness investigations and interpretation of economic analyses in the context of outbreak planning and containment, and outline considerations for providers, administrators, patients, and policy makers for infection emergency preparedness response.

Keywords. emergency preparedness; infection prevention; healthcare economics; SARS-CoV-2.

In infection prevention, interventions—such as outbreak investigation and planning, facilities management, flu vaccination campaigns, and day-to-day prevention of infections—can be evaluated in terms of the positive clinical outcomes per dollar spent at a hospital, system, or regional level. Deciding what to do within a healthcare facility with a fixed budget for patient safety is also a policy priority, as is identifying ways to deploy limited resources in the most effective and efficient way possible. Thus, budget impact analysis (BIA) and cost-effectiveness analysis (CEA) both play major roles in decision making.

Economic principles are often applied to make decisions about how to deploy resources to support emergency response and outbreak preparedness, staffing, surveillance, advanced diagnostic testing, and other critical tasks. BIAs focus on the direct costs of the intervention from the perspective of the entity who pays those costs (usually the hospital system or an insurer)—and the direct costs of the consequences of the intervention including subsequent inpatient, outpatient, or pharmacy costs that are more or less likely because of the intervention. Potential gains in quality or quantity of life, or costs that are borne by others, such as patients or society, are not considered in BIAs [1]. In contrast, CEAs center around weighing benefits, downsides, and costs of different interventions to identify the strategy that maximizes health outcomes while minimizing costs at the patient level; generally speaking, it is recommended that CEAs are conducted from both the societal and healthcare sector perspectives [2]. CEA methods can also be adapted to help decide between several different options for deploying limited resources to optimize health of the population.

Emergency outbreak preparedness is a particularly challenging setting for application of economic analysis for several key reasons. First, there are high levels of uncertainty, creating wide confidence intervals on the input parameters to any model, which can lead to a large range of potential outcomes and costs. Second, when faced with an unknown and potentially deadly new pathogen, patients, providers, and policy makers can be highly risk-averse [3, 4]. Third, costs and adverse outcomes may not be evenly distributed; harm and cost may be borne by a small group of patients, healthcare systems, or countries. For these individuals or groups, infection prevention interventions may be highly beneficial even if, for the average patient or healthcare system, a particular emergency response effort generates a high level of cost with no benefit.

Here, we discuss methods for economic evaluation and cutoffs for cost-effectiveness in infection prevention, with an emphasis on challenges that may arise in the setting of an emerging pathogen or outbreak, and discuss strategies for confronting these complexities.

RESOURCES AND REPORTING STANDARDS IN HEALTHCARE ECONOMICS EVALUATIONS

While a detailed discussion of cost-effectiveness research is outside the scope of this review, it could simply be stated that CEAs evaluate how much "bang for the buck" an intervention might yield. These analyses are conducted by examining how a new policy or intervention, relative to an alternative strategy (typically the established standard of care), impacts costs and

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health outcomes. This new intervention may be cost saving (eg, dominant, producing positive health benefits while also reducing costs) or wasteful (eg, dominated, producing less benefit than existing programs and costing more), or it can yield positive benefits but at an additional cost, or be both less effective and less costly than currently accepted clinical practice. If an intervention is neither dominant or dominated, then to help decision makers to know whether to adopt this new technology, it becomes useful to compare the dollars necessary to achieve 1 additional unit of effectiveness against an established willingness-to-pay-threshold.

While CEA research focuses on the value of an intervention as a function of economic costs and clinical effectiveness at the individual level, BIA focuses on the bottom-line cost of implementing an intervention. The major question BIA asks is: Is this affordable based on the size and composition of the patient population served and current resources available? BIA is typically conducted from the point of view of hospital administration and/or the payor, to determine how much it will cost to implement an intervention within a particular setting. Relevant costs in BIAs are those associated with the intervention as well as any downstream healthcare resources that are used as a consequence of being exposed (or not exposed) to the intervention. This is critical, because some interventions that are deemed cost-effective from a CEA may not be *affordable* from the point of view of a payor because they affect such a large number of patients, whereas some interventions that are not cost effective may have minimal impacts on the overall hospital budget and therefore may be adopted. Generally speaking, when requesting resources, infection control departments present BIAs, rather than CEAs. The Second Panel on Cost Effectiveness research is an excellent resource for further information about conducting high-quality healthcare economics evaluations, and the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist is a useful tool for evaluating them [5, 6]. The Veterans Affairs Health Economics Resource Center is another helpful resource, with specific recommendations for conducting various economic studies, including BIA [1].

Point-of-view is a critical aspect of CEAs and BIAs. Different stakeholders have different views of risks, benefits, and costs that must be taken into account when making decisions about whether or not to adopt a given intervention. The societal perspective is the broadest and includes costs related to healthcare utilization, informal caregiving, lost work and productivity, patient time to seek treatment, parking and transportation, non–healthcare resource costs, and many other items. Impacts on global supply chains and lost economic activity are also considerations from the societal perspective but have historically been less important to include in analyses of outbreak costs, as experience from the severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) outbreaks suggested that these impacts can be short-lived and full economic recovery after containment is typical; however, given the unprecedented scope of the coronavirus disease 2019 (COVID-19) outbreak, including widespread business closures, these historical models of broader economic impacts may not apply [7].

In infection prevention, the hospital perspective is often presented. This perspective includes include costs of supplies, personnel time (and lost personnel time and paid time off), admission surges, and consequences to facility reputation. Payor or insurer perspectives are often similar to that of the hospital administration, but local hospital considerations—such as injury to facility reputation and lost revenue due to paid time off for staff in the setting of an outbreak—would not be included as these costs are not borne by the insurer. It is important to note that, because hospitals are not reimbursed for supplies used in emergencies—such as respirators, medical masks, and gowns and gloves—these costs are entirely borne by the healthcare system. However, in certain emergency circumstances, these supplies may be provided through federal or state funding. Patient perspectives include only costs directly paid for by the patient, such as co-payments and deductibles, lost wages, over-the-counter medications, and childcare.

EXAMPLES AND APPLICATION IN INFECTION PREVENTION AND CONTROL

Within the realm of infection prevention, influenza vaccination of healthcare workers is an example of a cost-saving intervention that saves money by reducing staff absenteeism and paid time off [8]. From a policy and population level, childhood vaccination programs are estimated to save more than $10 for every $1 spent [9]. On the other extreme, there are dominated strategies that clearly are not cost-effective according to currently established standards, but that society has chosen to implement because these interventions prevent "never-events." A classic example is screening of the blood supply for bloodborne pathogens. Early screening strategies were found to be cost-effective at typical willingness-to-pay thresholds; however, enhanced human immunodeficiency virus screening with nucleic acid testing to detect infections during the window period is estimated to cost up to $11.2 million per quality-adjusted life-year (QALY) saved [10]. While this exceeds typical willingness-to-pay thresholds of $50 000–$150 000 per QALY, society has established a zero-risk blood supply as the only acceptable standard [11], so the practice is supported.

Another category includes interventions that lead to improvements in outcomes, but are not cost saving, and thus require investment from the healthcare system in order to implement [2]. In these cases, rigorous CEAs are useful to elucidate the optimal course of action. In instances in which a new strategy yields slightly more benefits but at a huge cost compared to the standard model of care, the resulting incremental cost-effectiveness ratio (ICER) may exceed the willingness-to-pay threshold being used by a decision-making body, in which case policy makers will likely decide not to pursue the strategy.

On the other hand, the ICER may be quite small because the incremental benefit is large while the incremental cost is small, leading to adoption of the new strategy.

A final and particularly complex category within the context of outbreak preparedness concerns interventions with unknown effectiveness in the setting of a novel pathogen, such as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In this context, patients, healthcare administrations, and providers have higher than usual levels of fear and risk aversion that impact decision making and planning [4, 12, 13]. At the outset, it may not be possible to calculate the economic costs of the outbreak because of the many unknown elements involved in this new setting (including new surveillance tests; new treatments; unknown duration of symptoms, mortality rate, and transmission rate; and unknown duration of outbreak, to name just a few). Therefore, it may simply not be possible to apply strict economic evaluations to guide early decision making during an initial outbreak, and it is possible that a post hoc analysis may find that the costs that were ultimately incurred were extremely high relative to the positive outcomes produced. This does not, necessarily, mean that the chosen course of action was not appropriate. There are other considerations that go into decision making than the short-term tradeoff between direct costs and patient health outcomes, particularly in settings with high levels of uncertainty.

Conversely, interventions implemented to halt the outbreak may be cost-effective or even cost-saving. Facility directors may employ a "press test" for interventions to combat high-profile pathogens. To protect a facility's reputation—which can have a major impact on a healthcare system's bottom line—decision makers may need to prevent against negative publicity by making certain investments that may not ultimately yield many QALYs. For example, while Ebola prevention programs are expensive and have limited utility in most healthcare settings (most hospitals in the United States will never admit a single Ebola patient), the potential downside of not having a program in place may be substantial. For example, the Dallas hospital where the first Ebola patient in the United States presented experienced a substantial decline in revenue and emergency room visits during the period immediately following the media exposure of the Ebola case [14]. This negative press led to more than $12 million dollars in lost revenue for the hospital over a 2-month period [15], although the harms resulting from the negative press were only clear in hindsight. This vignette highlights a key challenge in using CEA to guide emergency preparedness decisions. From the point of view of the Dallas Hospital, the costs of a limited response were high. However, from the point of view of society, insurers, and patients who simply chose to seek care elsewhere, there was minimal impact.

RISK AVERSION AND LOTS OF UNKNOWNS: PERENNIAL CHALLENGES

Ideally, decisions should be made with plenty of data from rigorous economic evaluations assessing the potential costs and QALYs generated from several potential infection control strategies. However, achieving this may not be feasible in outbreak and emergency settings. Decisions often must be made quickly, and risk aversion in the setting of unknown transmissibility patterns and mortality—coupled with intense media scrutiny—is extremely and understandably high, as the goal is to contain the outbreak and minimize risk to patients and providers. As an example, at the beginning of the Ebola outbreak, there were not enough data to estimate the number of lives saved by an Ebola prevention program, let alone to estimate the QALYs, especially when X-factors such as media coverage and the public response were unknown.

A major driver of decisions in pandemic infection prevention is risk aversion because the actual risk is unknown or difficult to quantify. If policy makers are risk averse, greater uncertainty in either the cost or the effectiveness of new technologies can result in less or more adoption of these technologies than would typically be expected. For example, recent data suggest that medical masks are noninferior to respirators for preventing influenza in healthcare workers [16]. Extrapolating beyond influenza specifically, this study suggests that pathogens that are transmitted via the droplet route can be safely prevented in most clinical care settings using medical masks. These medical masks are less expensive and more widely available than respirators, which are designed for small particle filtration and are superior for aerosol-based transmissions and aerosol-generating procedures [17]. However, despite this high-quality evidence, presented with a novel coronavirus, hospitals reverted to recommending respirators—and sometimes Powered Air Purifying Respirators—for healthcare workers in a variety of clinical care settings, including low-risk encounters [18]. This recommendation was driven by an abundance of caution and concerns about offering the highest levels of protection for frontline staff members in the setting of limited data and the unknown potential for aerosol-based spread, even if these protections may not be superior to less costly alternatives, such as medical masks [16, 17]. From the perspective of reassuring healthcare workers about their own protection, and ensuring a healthy healthcare workforce, recommending the highest level of risk protection upfront was a practical and reasonable choice, even if the conservative recommendation is later deemed to be unnecessary (and therefore "cost ineffective").

In real-world settings, it can be difficult to know if the infection prevention interventions were effective—and prevented what otherwise would have been a major outbreak—or if other forces drove outbreak control. Bundling of multiple interventions further complicates this picture. Because multiple interventions are generally introduced at the same time, it can be impossible to know which element of the bundle—if any—was effective and important for reducing transmissions. This lack of a counterfactual can make economic analysis challenging, even in a post hoc analysis. If few patients contract a novel pathogen because infection prevention interventions are effective, then it may appear that all of the funds spent on prevention were wasted, when in fact without the aggressive prevention strategy, millions would have been infected.

SOLUTIONS AND FUTURE CONSIDERATIONS

First and foremost, we must use information and data collected during current and past outbreaks to inform future responses. Lessons learned from the H1N1 outbreak—and ultimately from the COVID-19 pandemic—can be applied to improve outcomes and controls in the future. The use of advanced data analytic methods that allow for earlier detection and potentially containment of an outbreak before it takes hold on the population level is a promising strategy for reducing the costs associated with the emergence of novel pathogens. Applying these lessons will require ongoing vigilance about the persistent threat of a global pandemic in an increasingly interconnected world, novel research strategies to ascertain interventions that were and were not effective, and how to optimize resource deployment.

Because outbreaks of novel pathogens necessarily produce high levels of uncertainty, it is reasonable upfront to adopt an aggressive bundle-based approach to infection prevention, utilizing an array of measures targeted at multiple potential modes of transmission that may be more effective and also more costly (eg, recommending respirators rather than medical masks until more data are available about a droplet-based or aerosol-based transmission pattern). However, once more data are available, these protocols should be reviewed and updated with only effective strategies maintained. Although determining which elements of a multifaceted intervention were effective is challenging, additional mixed methods research applied to retrospective qualitative and quantitative data may help to delineate which bundle elements were effective and which were not and therefore help to guide future emergency responses.

In the future, developing general triaging protocols that can be broadly applied in any outbreak and then adapted after new information becomes available could yield savings by reducing time dedicated to developing a new protocol during every individual outbreak. A top-down approach—in which a general protocol is developed by a central federal agency—and then locally adapted for optimal use within individual healthcare systems would save precious time and resources. The current approach to SARS-CoV-2, which has largely been de-centralized, has resulted in an inefficient use of time and energy to develop protocols at the local level. A centrally directed and funded system—with allowance for local adaptations—would save time, money, and resources. This generalized prevention model could recommend broad, aggressive prevention strategies upfront (eg, recommend airborne precautions, contract precautions, and isolation) and slowly remove bundle elements as more information becomes available (eg, transition to medical masks rather than respirators once droplet-based transmission is confirmed). This general model of aggressive upfront care with frequent reevaluations and local adaptations balances the practical need for conservative action in the setting of uncertainty and high levels of risk aversion with economic considerations and the needs of a specific healthcare system.

CONCLUSIONS

Cost-effectiveness methods can be useful tools for allocating limited infection prevention resources by identifying the interventions that maximize health benefits for the largest number of patients. In the setting of a global pandemic, patients, providers, and healthcare systems are highly risk-adverse, which may tip the scales toward more, rather than less, aggressive infection prevention strategies. Further clouding the picture, the relative value of interventions and outbreak control efforts may depend upon the eyes of the beholder. In a pandemic setting, different stakeholders—the hospital system, society, the payors—are interconnected in ways they are not for other types of medical conditions; coordination of efforts requires local, regional, and national responses in a way management of noninfectious medical care does not. Additional research is needed to help quantify the costs of an outbreak from the points of view of multiple actors, including clinicians, administrators, patients, and policy makers.

Notes

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