Economic considerations in risk management: Lessons learned from H1N1 influenza

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ABSTRACT: The objective of this review study is to improve the proficiency of cost calculation and forecasting in pandemic risk management. The 2009 A/H1N1 influenza pandemic has generated additional data and triggered new studies that open debate over the optimal strategy for handling a pandemic. A point of improvement for the risk analysis of such crises that is often mentioned in lessons-learned documents from the World Health Organization and governments is the need for cost estimation of the pandemic response. The assessment of costs during a pandemic poses particular problems related to the appropriate modeling of the characteristic of the virus and the direct effects of an intervention and its impact on costs. Further difficulties arise when trying to relate those costs to overall societal welfare, such as choosing the appropriate societal costs for an intervention or assessing the value of statistical life. In this study, we explore the lessons learned and innovation emerging from the past crisis, with a focus on studies covering high-income countries. We review a number of academic studies and organizational documents that provide cost-effectiveness or cost-benefit analyses for A/H1N1 pandemic interventions since 2009. Our comparative analysis reviews each study's type of intervention, epidemiological model, type of costs included and cost-utility results with a possible conversion to cost-benefit. The result is an extensive reflection on the parameters that may drive the pandemic costs and the appropriate response, which is unique to our knowledge in both the breadth of coverage and the novelty of selected studies. At the cross-disciplinary level, this study stresses the need for an economic efficiency analysis in the risk governance process to distribute financial resources in the most efficient way.

Keywords: H1N1 influenza, pandemic, cost-effectiveness, cost-benefit, value for money

1. INTRODUCTION

The 2009 pandemic of the H1N1 influenza virus, commonly known as swine flu, has been a very interesting challenge to global risk planning. On one hand, it confirmed the fears of the extremely rapid and unstoppable dissemination of the virus worldwide through international travel. On the other hand, it was of mild severity compared to the estimations usually found in pandemic studies.

Indeed, the recently estimated case fatality ratio of H1N1 was of 0.02% (Van Kerkhove *et al*., 2013), which means that 2 out of 10,000 people formally diagnosed with the disease would die. For comparison, studies on cost effectiveness published before 2009 usually accounted for a case fatality rate at least ten times higher, referring to previous flu epidemics (Potter, 2001) such as the 1957–1958 Asian flu (estimated case fatality ratio of 0.13%) and the 1968–69 Hong Kong flu (case estimated fatality ratio <0.1%), or even the devastating 1918–19 Spanish flu pandemic (estimated case fatality ratio of 2%). Despite the controversy over the past pandemic numbers, and without disregarding both the clear difficulty in assessing the case fatality ratio—especially at the beginning of the infection—and the legitimate fear regarding the mutation power of the influenza virus, there was no doubt, early into the pandemic, that the H1N1 was mild. (Briand *et al*., 2011)

Beginning in April 2009, the pandemic-fighting mechanism carefully prepared by the World Health Organization (WHO) under the new International Health Regulation (IHR) was triggered and relayed within each country through local pandemic plans. According to those national and local plans, and following the local risk assessment committee and experts' recommendations, a set of different interventions, such as airport screenings, antiviral stockpiling, vaccination campaigns and banning public events and/or school closures, was implemented in each country. It was clear that the global network of alerts and notifications established by WHO and the member states was working to some extent (Briand *et al*., 2011)

However, interventions were launched on previous assumption of their cost effectiveness under more severe conditions and without re-consideration whether there would be cost efficient considering the mildness of the current pandemic. While this proposal may seem radical, this point of improvement is often mentioned in the lessons-learned documents from WHO and various governments (WHO, 2011: "A methodology for measuring the economic costs of interventions and the overall pandemic should be taken into account during pandemic preparedness").

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1.1 Pandemic influenza – Value for money in a crisis context

Indeed, detailed examination of pandemic plans in place in 2009 shows a lack of cost assessment during the risk analysis and response phase. Some documents do state that the interventions within the pandemic plan are considered cost effective at country level, often referring to the results of past studies. Past studies on cost effectiveness are pointing toward vaccination and antiviral stockpiling as successful strategies, while rejecting others, such as school closures and air traffic restrictions. However, as explained earlier, the 2009 H1N1 pandemic did not fit the same criteria of severity as its predecessors and there is no sign that a re-assessment of the cost effectiveness of each intervention has happened during the H1N1 decision process in order to take into account the new characteristics of this epidemic. Does it mean that the crisis management was wrong or suboptimal, or that the decision makers were oblivious of the costs incurred? Probably not, but it may have left the impression that the last pandemic might have cost less or the response would have been shaped differently, would decision makers have had the opportunity at the time to better understand the costs and benefits of the interventions in that particular context. This perceived "overreaction" was reinforced by the financial crisis, which led the public to question the actions of governments (Barrelet *et al*., 2013). From an ethical and organizational point of view, a lack of systematic cost effectiveness evaluation during a health crisis may not be seen as a problem: lives must be saved, and quick action must be taken. However, it causes a number of issues in the long term, such as depleting the financial resources left to handle other risks or health issues and lowering the confidence of citizens in their state and government to evaluate a situation accurately. It also questions the ability of decision makers to reassess the true efficiency of all possible interventions during a more severe crisis. What if a virus twice deadly as the Spanish influenza were to appear? Would some measures, such as airport scanning or wearing masks, still be inefficient? What about school closures? On the contrary, what if a pandemic twice as mild as H1N1 occurred: is vaccination still cost efficient in such a scenario? How can we make sure that the strategy decided upon to manage a pandemic influenza bring the most value for the money to citizens and saves the most lives for the least cost?

1.2 Assessing the cost effectiveness of interventions under uncertainty

The assessment of costs for pandemic influenza is not a simple task. It poses numerous problems related to uncertainties regarding the occurrence of the pandemic, the characteristics of the virus (case attack rate, case fatality ratio and age-specific incidence) or the medical controversy on the magnitude of side effects (antiviral resistance, herd effect). Further difficulties arise when trying to relate those costs to overall society welfare, such as choosing the appropriate societal costs for the measure or assessing the value of statistical life (VOSL). Finally, the economic data on past pandemics is required to confirm the planned intervention's costs, but it is hard to gather methodically as it is entangled in the local cost system.

To address the above issues and understand all points of variability in cost assessments, we decided to review a number of studies on cost effectiveness post 2009 for A/H1N1 pandemic influenza. The underlying hypothesis is the opportunity to construct a catalog of data and models for costs of pandemic influenza that could help predict, compare and monitor the costs and effectiveness for each intervention; and, by addition, as a total at country level. To our knowledge, such models have been tested in the past to compare two or three interventions under different scenarios, but there are no global studies that simulate the whole range of possible interventions. On the contrary, in this study, we want to keep the range of interventions as broad as possible in the light of a wider spectrum of milder or more severe pandemics and include studies in our review on interventions that, although they may have been neglected under past assumptions, might prove efficient in other cases.

2. METHODOLOGY

The goal of our study is to select and analyze significant papers on cost effectiveness for each type of possible pandemic interventions, and compare their methodologies and results, to estimate the costs with a global understanding of leading parameters and a reasonable uncertainty. Our selection focuses primarily on developed countries (under the UN Millennium Development Goals region) to facilitate the comparison of costs under similar conditions, but results could be applied to other countries. Only studies related to H1N1 pandemic and published after 2009 were selected. Studies on other types of pandemic influenza or seasonal influenza definitions were discarded unless they brought a specific enlightenment to the topic of cost measurement. For some interventions that lacked cost studies, we also considered studies that provided information on the intervention details, which allowed us to derive a possible methodology for estimating costs and benefits.

We selected the cost studies through a systematic search in EBSCO Business Premiere and PubMed databases of the terms "cost," "effectiveness," "benefit" and "H1N1" in conjunction with the intervention's category or subcategory, as mentioned in our first paragraph. For interventions where the search yielded no satisfying results, we limited our search to the words "cost" and "H1N1" in conjunction with the intervention's subcategory.

2.1 Type of intervention

In today's battle against influenza pandemics, the measures to counter them can be divided into three main groups: preparedness, containment and mitigation (Cook, 2013). The three groups "Prevention, Containment, Mitigation" are based on the timing and purpose of the measures. However, containment and mitigation measures happen both once the epidemic has occurred and (often) simultaneously, in contrast to preparedness. Therefore, we should perhaps consider only two groups: "Off Crisis/Preparedness" and "In-Crisis/Response," with the latter containing both the containment and mitigation measures. This

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division seems to work in terms of cost analysis, as the pandemic response assessment works in an environment in which the pandemic already exists and that contains a certain amount of known characteristics, as opposed to preparedness, where the probability of the next pandemic's occurrence is unknown.

Type	Category	Public Measures/ Interventions	Type	Category	Public Measures/ Interventions
Off-Crisis Preparedness	Surveillance	Disease surveillance networks	In-Crisis Containment & Mitigation	Antiviral	Antiviral treatment
	Planning	Emergency preparedness planning			Antiviral prophylaxis
		Emergency preparedness drills		Vaccination	Low-efficiency /seasonal vaccine distribution
		Prevention behavior programs			High-efficiency vaccine (targeted to specific agent) production and distribution
	Stockpiling	Stockpiling antiviral medicine		Hospitalization	Observation
		Stockpiling low efficacy vaccine			Respiratory assistance
In-Crisis Containment & Mitigation	Trade & Travel restriction	Travel restriction		Social distancing	School closure
		Border scanning			Stay at home (self-isolation)
		Close borders to people			Business closure
		Close borders to goods			Ban on public gatherings
		Ground airplane travel			Public transportation ban
		Tracking exposed people		Hygiene recommendation	Face mask
	Quarantine	Quarantine existing cases			Prevention behavior recommendation
		Quarantine hospital		Animal to Human transmission	Animal culling
					Food restriction

Table 1 – Common interventions before, and at the time of, an influenza pandemic

2.2 A framework to review cost studies on pandemic influenza

While gathering studies on costs for pandemic influenza, we first considered performing a meta-analysis of the effect sizes (i.e., on cost-benefit and cost-effectiveness ratios). However, due to the limited number of studies and the lack of standard in the inputs and outputs, no satisfactory results have been obtained. Instead, we developed a framework to compare the differences in the studies and provide a ground for further studies to convert the results to a common basis. Our framework is presented below.
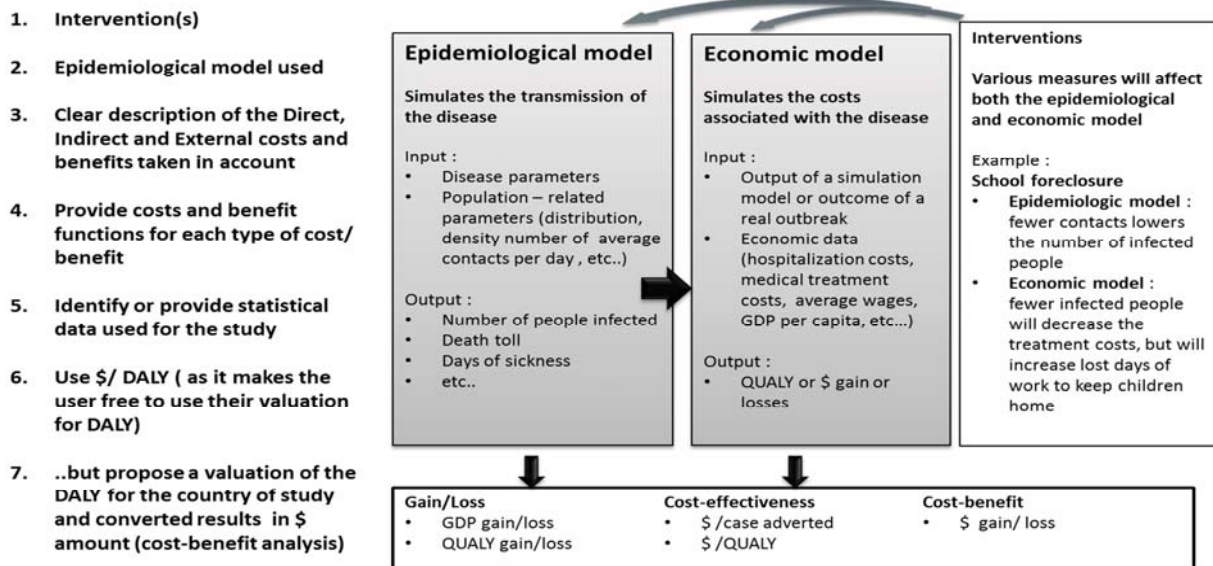

Fig. 1 – Framework proposal for cost estimation of influenza pandemic interventions

A very important component is the epidemiological model, which is used to predict the evolution of the pandemic, plan the necessary resources; or, in our case, estimate the economic outcome. The epidemiological model is a mathematical representation of the evolution of the health consequences of the virus, given certain characteristics from the medical field and statistical observations of the human population. The output of this model is a forecast of how many people will be affected by the virus, without and with interventions (such as the measures described above). The output of the model can later be combined with an economic model in order to estimate the economic consequences of the virus and determine the cost effectiveness or cost-benefit ratio of an intervention. Both models are fed with statistics that depend on the population studied. Finally, the result can be expressed in various ways, depending on how the health benefits are accounted for. For instance, an averted case of influenza could be expressed as Quality-Adjusted Life Year (QALY) or DALY (Disability-Adjusted Life Year), or as a monetary unit. When the health unit is not converted, the result is called a measure of cost effectiveness; and, when all benefits are expressed in

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monetary unit, the result is called a cost-benefit analysis (CBA). The framework proposed is compatible with the recommendation of the World Health Organization for the evaluation of health programs.

3. ADDED VALUE FOR THE POST-2015 FRAMEWORK FOR DISASTER RISK REDUCTION

Our work supports the implementation of the Hyogo Framework for Action by providing a reflection on the probability of extreme scenarios and the need to adapt preparedness accordingly. Influenza pandemics occur every 40 years on average, and viruses spread faster as a result of globalization. At a time where we may feel that infectious diseases are no longer a threat to the modern world, we should not neglect preparedness for all type of situations: very mild, as with the last A/H1N1 pandemic, or very severe, as with the Spanish influenza. Our main reflection is on how to assess the value for money (Jackson, 2012), or economic efficiency of interventions during recurring influenza crises. The goal is long-term risk management and the wisest way for governments to invest in the most efficient interventions to protect citizens now and in the future.

In order to do this, governments need appropriate studies that assess the cost effectiveness of the potential interventions. Research should strive to develop and encourage national and international cost-effectiveness and cost-benefit standards for health disaster risk, similar to those that presently exist for regular or ecological programs (Armantier and Treich, 2004). Our work, therefore, advocates for long-term economic efficiency to be considered in the Post-2015 Framework for Disaster Risk Reduction. We believe there is a need for a dynamic cost-efficiency assessment to be included in all steps of disaster risk management in order to maintain the financial sustainability needed to handle recurring infectious disease events and distribute scarce financial resources in the most societally efficient manner.

4. CONCLUSIONS

An immediate observation while searching for academic studies on cost effectiveness is how unbalanced the number of studies is, depending on the type of intervention. Some measures, such as vaccination and antiviral drugs, are widely studied, while others, such as containment and non-pharmaceutical mitigation, remain out of focus. Similarly, the pandemic response is often studied, but little attention is given to the cost effectiveness of preparedness measures. This shows a need for more diversity in cost-effectiveness studies beyond the standard in-crisis response.

The main conclusion in our study is the need for researchers to systematize their studies on pandemic costs. While we understand the urge to provide academically challenging papers with unique models and innovative methodologies, the huge differences in both the input parameters and methods of expressing the results make it difficult to compare studies. In our comparison, we propose a simple framework to help researchers clarify their input and express their results in a way that can be compared with others and confirm global expectations regarding costs. Further research could propose a unified, detailed framework model to assess and compare pandemic intervention costs at country level that could be tailored for each country and crisis and serve as a basis for cost estimation, as well as a starting point for innovative studies on cost effectiveness for influenza. On top of harmonization, researchers could also try to back up the results they obtain through modeling with real-life data whenever possible. Finally, our study also stresses the need to include a larger variability of scenarios. On average, studies only reproduce a range of scenarios based on past medical and epidemiological data, which represents only a hundred years of history. However, we have no evidence to confirm that the last century fully represents the boundaries. Extreme cases may have low probability, but disasters like the Fukushima Daiichi nuclear accident remind us that low-probability events do not mean zero probability. We should be able to know, beforehand, the best response for both a very dire and a very mild influenza pandemic; and, with the help of simulation, those scenarios should be evaluated in future cost-effectiveness studies.

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Understanding the role of human and nonhuman actants in post-disaster contexts: a tentative deployment of Actor Network Theory to evaluate its usefulness.

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ABSTRACT: In the aftermath of disasters attention naturally focuses on the impacts humans experience during rescue, recovery and rebuilding. Resilient outcomes are desirable but by no means guaranteed, and the consequences are usually attributed to the actions of humans. In a novel deployment this research uses an Actor Network Theory (ANT) lens to reanalyse case study data from three disaster theatres. It reveals the impact of nonhuman actants upon human actants, and their consequences for recovery efforts and resilience outcomes. In particular it exposes the potential economic retardation that food aid can inflict on fragile societies; the value of coherent policies and processes for resilient reconstruction in highly structured societies, and; the mixed blessings arising from the presence of TV cameras in disaster theatres. It concludes that using an ANT lens sensitises researchers to the influences that nonhuman actants can exert in dynamic post-disaster contexts, but that the use of purist ANT approach to solving problems within disaster theatres is not a practical proposition.

Keywords: Actor Network Theory, human, non-human, actant, influence.

1. INTRODUCTION

Post-disaster reportage often concentrates on the catastrophic and harrowing human impact together with heroic acts of mercy: a useful, and from the aid agencies perspective vital by-product of such information is the mobilisation of donors. Post-disaster relief and recovery activities and the resilient reconstruction of communities involve the interaction of interrelated individuals and agencies in pursuit of the public good (James, 2008). Such scenarios may be thought of as loosely coupled complex adaptive systems, whose component parts are constantly being influenced by the activities of others (Geli-Mann, 1994). Subsequent sober and analytical reviews of the same events balance success with failure in order to learn and improve performance in future disaster theatres.

It is inevitable that the bulk of data is collected from key individuals in major organisations associated with disaster recovery and reconstruction, and it is unsurprising that little consideration is given to the nonhuman actants that they direct or influence: examples include food aid, shelter, resources and processes associated with reconstruction, and the policies and protocols associated with relevant government agencies. The policies and procedures of each organisation active within a disaster theatre are primarily designed to focus their attention on achieving their organisational mission and consequent strategic goals, and although they are enshrined in writing they are generally considered to be artefacts of human activity, and therefore broadly linked to humans. In a similar way the presence of television cameras and associated media paraphernalia within a disaster theatre come about as a consequence of the human activity associated with news agencies fulfilling their - ultimately commercial - objective of informing the broader public (Brewer et al, 2014).

2. ACTOR NETWORK THEORY

Actor Network Theory (ANT) suggests that nonhuman actants share the stage equally with human actants when considering problems that occur at the socio-technological interface, and while ANT conventionally has been utilised to consider the challenges faced when integrating high-level technology systems with humans this paper speculates that the technique has the potential to reveal useful lessons when considering the complex problems faced during disaster recovery and reconstruction. ANT suggests that non-human actors (known as actants) - such as policies, food aid, or television cameras - are possessed of their own motivations, which cannot be automatically assumed to be congruent with the intentions of their creators (Hanseth & Montiero, 1998). Whilst this radical position is not without its critics (e.g. Amsterdamska, 1990) it does provide a framework to allow a more complete examination of the influences on the development of outcomes in a given situation: "Newton did not really act alone in creating the theory of gravitation: he needed observational data from the Astronomer Royal, John Flamsteed, he needed publication support from the Royal Society and its members (most especially Edmund Halley), he needed the geometry of Euclid, the astronomy of Kepler, the mechanics of Galileo, the rooms, lab, food, etc. at Trinity College, an assistant to work in the lab, the mystical idea of action at a distance, and more, much more. The same can be said of any scientific or technological project" (Goguen 1999).

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