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The Cost of Influenza Disease Burden in U.S Population

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Abstract

Background: influenza epidemics are responsible for substantial morbidity and mortality every year in the United States. Vaccination strategies to reduce disease burden have been implemented. However, only few previous studies have systematically estimated the annual economic burden of influenza epidemics in the elderly population as the most vital part in understanding the economic burden, an estimate necessary to guide policy makers effectively.

Objective: We estimate age specific disease burden for the elderly population (65+), and medical and indirect costs attributable to annual influenza epidemics in the United States. We estimate the total economic burden of annual influenza epidemics using also projected statistical life values in $34.7 billion (C.I. $13.2, $74.4).

Conclusions: Our study indicates a lower economic burden than estimated in previous studies associate with the elderly group, mainly due to higher vaccination rates. However, these results highlight the enormous annual burden of influenza in the US. While hospitalization costs are important contributors, lost productivity from missed work days and lost lives comprise the bulk of the economic burden of influenza.

Keywords: Influenza; Economic burden; United States

Research Highlights

- Influenza economic burden has rapidly declined during the last decade for highly-risk groups as the elderly group (65+).
- Hospitalization costs are important contributors, however, lost productivity from missed work days also for caregivers and lost lives comprise the bulk of the economic burden of influenza.
- We propose simple economic tool (ROI) to address economic burden measurement, as we find it to be 777$ Cost of Burden per Citizen (CBC).

Introduction

Influenza has attained an unprecedented degree of attention in recent years as a result of disruptions in vaccine supply and distribution, and concerns about the nation's ability to respond to an influenza pandemic. Influenza has a long history, however, of causing substantial morbidity and mortality nearly every year. Thus, vaccination recommendations targeted to high-risk groups and their contacts like the elderly population have had an impact on U.S population with higher vaccination rate in this high-risk group (70.3% vaccination rate in 2014 vs. 64.4% in 2000s) [1]. Deaths by influenza and pneumonia in the U.S from 1950 to 2013 (per 100,000 population), have also decreased from 36.8 deaths in 1990 to 15.9 deaths in 2013.

Thus, economic considerations are an essential ingredient to effectively guide policy-making for influenza vaccination. Numerous studies have considered the cost effectiveness of influenza vaccination [2-4]. However, only few previous studies systematically estimated the economic impact of influenza in the U.S focusing on the impact of pandemic influenza [5].

Literature Review

Estimation of the economic burden of influenza has not been systematically studied until late-90`. Meltzer et al. estimated the possible effects of influenza pandemic in the United States and analyzed the economic impact of vaccine-based interventions, using death rates, hospitalization data, and outpatient visits. The outcome of the research was 89,000 to 207,000 deaths; 314,000 to 734,000 hospitalizations; and 18 to 42 million outpatient visits with an estimated economic impact that would be US$71.3 to $166.5 billion.

Other studies studied specific items in the economic burden of influenza such as Influenza-associated hospitalizations in the United States [6,7]. Molinari et al. research estimated the annual impact of seasonal influenza in the US by measuring disease burden and associated medical and indirect costs and also presented projected costs by age groups. Specifically, the research explored the total economic burden of annual influenza epidemics based on the 2003 US population. The study found that annual influenza epidemics resulted in an average of 610,660 life-years lost, 3.1 million hospitalized days, and 31.4 million outpatient visits, all concluded to a total economic burden of $87.1 billion and for the elderly age group a total economic burden was $65 billion.

We based our cost valuation method of Influenza disease burden in U.S population on Molinari et al. research. Furthermore, we focus our study on the elderly population as the highest risk group, explore additional costs that hadn't been discussed yet such as lost productivity from missed work days also for caregivers and add new and update date based on 2015 data.

Thus, we find, as elaborate in the results section, that Influenza economic burden has rapidly declined during the last decade for highly-risk groups as the elderly group (65+) and that hospitalization costs are important contributors, however, lost productivity from missed work days also for caregivers and lost lives comprise the bulk of the economic burden of influenza.

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Research Method

We use both payer and societal perspectives to estimate the economic burden of influenza in the U.S based on previous studies [2,5]. These studies use a probabilistic model and publicly available epidemiological data estimating the number of influenza-attributable cases leading to outpatient visits, hospitalization, and mortality, as well as time lost from work absenteeism or premature death. Also, studies, similar to our study, estimate healthcare resource utilization associated with influenza cases as were their medical and productivity (indirect).

The economic burden of influenza at the population level is then a function of the cost per case of influenza and the number of cases. We conservatively consider the elderly age group to be high-risk group. We cluster this group into four categories based on final outcomes: (1) ill but not medically attended; (2) ill with outpatient visit(s) only; (3) ill with hospitalization; (4) ill followed by death [2].

The number of influenza cases in any year depends on the influenza infection rate, mortality and morbidity rates given influenza infection, as well as the size of the population. To estimate health outcome rates in each of the four categories, we use the following sources. Age-specific influenza attack rates were based on surveillance studies and published literature [8-10]. Attack rates were 9.0% (range: 6.6%-11.4%) for the elderly group. For the primary analyses using the influenza-attributable hospitalization and mortality rates, we use estimates based on underlying respiratory and circulatory conditions. Rates of outpatient visits attributable to influenza were based on published studies that account for age-specific variation in health care utilization [6,7,11]. The probability that an individual with influenza would not seek medical attention, i.e. a case not medically attended (CNMA), was assumed to equal one minus the sum of the probabilities of the other outcomes: outpatient treatment only (OPvisit), hospitalization (Hosp), and death given influenza infection (Death).

This is represented by the following expression:

$$Pr(CNMA|flu)=1 - Pr(OPvisit|flu) - Pr(Hosp|flu) - Pr(Death|flu).$$

Here $Pr(\cdot|flu)$ stands for probability of a particular final outcome given influenza illness. We combine health outcome rates with US Census population estimates by age group in 2015 to estimate the number of influenza cases in a year by final health outcome (Table 1).

Variable (Inputs), [1,3,10]	Mean	S.D
% Elderly of population	14.2%	0
Annually attack rate	9.0%	0.024
% of Pneumonia and Influenza	10.6%	0.1
% of death due to P&I	7.6%	0.01
% of 65+ population deaths due to Influenza	85.0%	0.8-0.9
Variable (Outputs), [1,3]	**Mean**	
# of annually infected (+65)	40,23,367	
outcome composition [3]		
will not go to the doctor	32.12%	
Light impact	62.50%	
Mild impact	4.21%	
Severe impact/death	1.17%	
Total impact	1	
Outcome composition - #	**#**	
will not go to the doctor	12,92,305	
Light impact	25,14,604	
Mild impact	1,69,384	
Severe impact	47,073	
Total impact	**4,023,367**	

Table 1: Model variables – quantities.

We postulate socio-economics disease burden as indirect costs based on recent literature data [2,4]. For hospitalized cases, costs were based on days of productivity lost calculated as the sum of length of stay (LOS) plus outpatient visits (Table 2). We consider elders family members that are in the labor force and are likely to experience work interruptions due to visitation and care giving. Days of productivity were valued at the average daily wage in 2015 of $187 [2] as shown in Table 3. We also took into consideration the Present Value of Loss of Earning (PVLE) based on the median elderly wage in the U.S for 2015 and the days of productivity lost [2].

Another aspect of evaluation is statistical life estimation as a critical part in disease economic burden analysis since it captures the socio-economic cost. For example, societies depend on a well-functioning transportation infrastructure, which has it metric costs for the public. Individuals, as policy makers, make decisions every day that reflect how they value health and fatality risks, such as driving a car or the decision not to be vaccinated.

We focus on applying previous econometric models to evaluate the Statistical Life Value (VSL) of Influenza economic burden in the elderly population in the U.S Measuring VSL is determined by the individuals` willingness to pay (WTP) [12-15]. We calculate age specific statistical value based on Viscusi and Aldi econometric meta-analysis data using 2015 elderly median annual wage to apply in our model.

Results

Consistent with earlier studies, our results indicated 4.02 million cases of influenza based on 2015 U.S population demographics. Case-patient accounted for 188,785 hospitalization days while 18,368 cases of the elderly population led to death, while previous studies the case-patient accounted for 136,059 hospitalization days (2003 U.S population data) [2]. Economic burden of societal perspectives was also measured

Direct costs [3]	Mean	S.D
will not go to the doctor	4	3
Light impact	312	1,989
Mild impact	14749	29,789
Severe impact	54029	124,249
Direct costs	**Medical cost**	
will not go to the doctor	49,93,468	
Light impact	783,792,059	
Mild impact	2,49,82,21,757	
Severe impact	2,54,33,29,314	
Direct costs	5,83,03,36,598	

Table 2: Direct costs ($, 2015).

Cost of death	Mean	S.D
# of all deaths	26,73,707	
% of death due to influenza	7.60%	0.71%
% CDC estimation of direct P&I	10.60%	2.10%
% of 65+ population deaths due to influenza	85%	6.30%
# of deaths per year of 65+ due to influenza	18,368	
Medical cost of death per patient	48,274	1,01,991
Value of statistical life		
# elderly population	4,47,04,074	
WTP	445	
Total VSL ("1 life")	9,213	
Life saves	21,59,018	
Total VSL	19,89,15,24,767	

Table 3: Cost of death and VSL estimation [9,10,14,15].

Total economic burden	Costs	% of costs from total burden
Total direct costs (medication, examination, hospitalization and etc.)	8,28,59,93,163	23.90%
Total indirect costs	5,66,66,09,627	16.30%
Cost of death	88,66,65,505	2.60%
Total VSL	19,89,15,24,767	57.30%
PVLE - Present value of loss of earning	1,11,98,549	0.00%
Total economic burden 65+, US	34,74,19,91,611	100.00%

Table 4: Total economic burden ($, 2015).

as indirect costs of death. We used two separate methods: (1) the value of VSL and (2) the present value of lost earnings (PVLE), while VSL includes the value of lost productivity as well as the intrinsic, or social, value placed on human life [2,12,13]. To wit, the impact of social economic burden in the age-specific group we examined is a vital part of the total economic burden. Thus, measuring the economic burden in the elderly population indicates total direct costs are 16.8% of the total burden ($34.7 billion), while indirect costs (work loss and the cost of death) are 23.4% of the total burden [16-18]. Also, if assuming 2015 US population elderly is 14.2% of total population (44.7 millions), the Cost of Burden per Citizen (CBC, Total burden/ Elderly population) is $777 per citizen (Table 4).

Discussion

We estimate that annual influenza epidemics economic burden has declined in related to previous studies, representing public awareness and governmental efforts. While, most recent study was based on 2003 data [2], assumed total economic burden in this age specific group in $56.1 billion, our results indicate the total economic burden of annual influenza epidemics using also projected statistical life values amounted to $34.7 billion (C.I. $13.2, $74.4).

Further research is necessary to identify the most efficient and effective methods of minimizing influenza disease in the elderly and its contribution to the annual economic burden of influenza epidemics. As for a future study, cost benefit analysis could be conducted for different vaccination strategies to assist governmental efforts.

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