Review Article

Economic impact of acute respiratory disease pandemics: A scoping review

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Background: The economic impact of acute respiratory disease pandemics has yet to be specifically systematically reviewed. The aim of this scoping review is to identify and classify the economic impacts and its values and ranges. **Materials and Methods:** We conducted a literature search across three key databases using an extensive list of keywords. Then, we included studies which explored direct and indirect costs as well as broader economic impact associated with different nine acute respiratory diseases, i.e., pandemic and seasonal influenza, avian influenza, equine influenza, swine influenza, severe acute respiratory syndrome, coronavirus disease 2019, Middle East respiratory syndrome, H1N1, and H7N9. **Results:** We included 62 studies in English language between 1987 and 2020, mostly from the countries of East Asia and Pacific pertinent. We classified the economic impact into 5 main categories and 18 subcategories. The main categories were macroeconomic impacts, impacts on health cost, industry, businesses and trade, and education. **Conclusion:** Respiratory disease pandemics have widely impacted different sectors of economy such as the direct cost on macroeconomic, providing and receiving health services, disease management, industries, business and trade, education, and indirect costs due to productivity losses. However, lots of the reviewed studies were unable to quantify the actual economic cost of these impacts. This made it challenging to conduct any kind of quantitative comparison of the results. A key priority for future research is to develop standard methods to quantify the broader economic costs of respiratory disease pandemics. Understanding the total economic impact of respiratory disease pandemics is a key step to inform national and international priority setting for disease prevention and pandemic control interventions.

Key words: Acute respiratory diseases, economic, pandemic

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INTRODUCTION

There is a new public health crisis threatening the world with the emergence and spread of 2019 novel coronavirus,[1] which is the most serious public health crisis in most of our lives and the most significant geopolitical event of our generation.[2] It is demonstrated that coronavirus disease (COVID-19) is the most economically costly pandemic in the world, after the most serious global health crisis of Spanish flu in 1918,[3] because, after its declaration as a world health emergency by the World Health Organization, it has affected almost $90 trillion of global economy.[4] Furthermore, COVID-19 caused sudden economic disruption in almost every area of human endeavor. The most affected sectors are health, education, travel and financial sectors, hospitality, sports, event and entertainment industries, and financial markets.[3]

The outbreaks have been around for thousands of years, even in this modern era.[5] The world had witnessed many epidemics.[6] Among them, acute respiratory disease pandemics have affected the lives of more than one billion people worldwide and were the predominant cause of mortality and morbidity.[7] Acute respiratory tract infections were the most common diseases affecting all individuals

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irrespective of their age or gender.[8] It is estimated that, every year, influenza leads to respiratory tract infections in 5%–15% of the population and severe illness in 3–5 million people.[4] For the last two decades, other major pandemics associated with coronaviruses (such as H1N1, severe acute respiratory syndrome [SARS], and Middle East respiratory syndrome [MERS]) occurred randomly at irregular intervals[8] and had severe global health impacts.[9] Like wars and sociopolitical shifts, contagious diseases have changed the economics and politics of the world throughout history.[6] These threats differ widely in terms of severity and probability, having varying consequences for morbidity and mortality, as well as for a complex set of social and economic outcomes.[10]

Nowadays, it has become clear that medical, political, and scientific communities across the globe are not sufficiently prepared to deal with another outbreak of a pathogenic virus,[1] because infectious disease threats – and the fear and panic that may accompany them – map to various economic and social risks. When critical human resources such as engineers, scientists, and physicians are affected, productivity impacts can be magnified. Moreover, fear of infection can result in social distancing or the closing of schools, enterprises, commercial establishments, transportation, trade, and public services – all of which disrupt economic and other socially valuable activities.[10]

Although respiratory disease pandemics have had significant economic effects on human societies, the scope and the extent of those effects have not yet been well studied. Thus, the aim of this scoping review is to identify and to classify the economic impacts of those pandemics.

METHODS

We conducted a scoping review of literatures on the economic impact of respiratory disease pandemics, using three main databases, i.e., PubMed, Scopus, and Web of Science. Initially, keywords (free text terms) were identified by the authors through a brainstorming process. The identified keywords were refined and validated by a team composed of two university academic members and two health-care managers. The search strategy was formulated using Boolean operators. The formula was searched in the field of title or title/abstract in online databases. The search line was: TITLE ("H1N1" OR "SARS" OR "Middle East Respiratory Syndrome" OR "Severe Acute Respiratory Syndrome" OR "H5N1" OR "H7N9" OR "MERS" OR "flu" OR "influenza") OR TITLE ("Coronavirus disease 2019" OR "SARS-CoV-2" OR "Covid-19" OR "2019-nCoV" OR "COVID 2019" OR "Wuhan 2019-nCoV" OR "Wuhan 2019 novel coronavirus" OR "wuhan 2019" OR "severe acute respiratory syndrome coronavirus 2") AND TITLE-ABS-KEY ("economic impact" OR "socio-economic impact") AND NOT TITLE-ABS-KEY (vaccin*)).

To identify relevant articles, an initial title and abstract screening was conducted to identify potentially relevant studies. Next, full text of relevant studies was read and selected based on the following inclusion criteria: (i) studies which explored direct costs (medical and nonmedical), productivity losses, and wider societal impact that could be expressed in economic terms or "broader economic impact" and (ii) articles in English. We excluded studies that (i) did not discuss acute respiratory diseases, solely focused on clinical aspects; (ii) without available abstracts or full text or references; and (iii) articles without appropriate data (just focused on strategies and recommendation).

When all screening and extraction were completed, disagreements on relevance were discussed. Finally, 62 of 315 articles that addressed the research criteria were selected and deeply reviewed.

In order to better apprehend the scope and significance of results obtained, after reviewing all studies, all appropriate data were extracted from studies and categorized into 31 categories. All of those series were classified again and again according to the most relevant economic impact by reviewing data several times and matching the suitable information with each other. Finally, 5 categories (a below) and 18 subcategories were finalized.

RESULTS

Study characteristics

We included 62 full-text studies in English for the time period of 1987–2020 [Figure 1]. Most studies (45 of 62) have been published between 2010 to 2020. More than half of studies published in that period were related to the seasonal or pandemic influenza while the rest were considered other acute respiratory diseases [Table 1].

As depicted in Table 1, the majority of studies (47 of 62) were done in one country, mostly in high- and upper-middle-income settings, particularly in the United States and Italy (11 and 9 studies, respectively). Two single-country studies were identified from lower-middle-income countries (Cambodia and India).

As presented in Table 2, we classified the economic impact of acute respiratory disease pandemics into five main categories, i.e., macroeconomic, health system cost, industry, business and trade, and education. When needed, each category was also divided into some related subcategories. For instance, for health system cost, some studies focused on specific types of cost such as hospitalization, clinics,

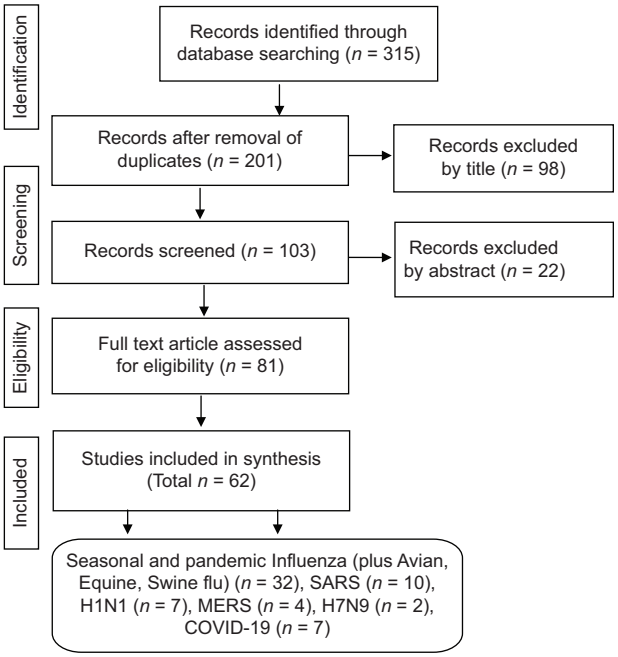

Figure 1: Study selection and data abstraction

drugs or immunization costs, while others showed the cost of diseases without regarding the type of cost. Economic impact of respiratory disease was presented in different ways in reviewed studies. For instance, some studies showed the economic impact in monetary terms ($), some reported that as the percentage of loss (%). some studies presented the economic impact as the number of persons, staff, visitors who got affected or the number of sick leaves which asked (N) or with the day or hour of loss or deficit (D/H) [Table 2].

In Table 2, we presented the economic impact of respiratory diseases as found in reviewed papers per category.

Macroeconomic impacts

Macroeconomic impacts of pandemics of respiratory diseases were expressed in 53 of 62 studies in different ways in the reviewed articles: impacts on economic indices, welfare and well-being, productivity loss, broader additional costs or burden, and projected economic impacts. Paying attention to the economic indices,[11,16,19,25,30-32,34,37,41,44,48,49,55] gross domestic product (GDP) percentage loss is the most common reported economic impacts in reviewed studies. In the USA, the UK, Peru, Thailand, Southeast Asia, South Africa, and Uganda, GDP loss was reported <1% because of disease such as flu and H1N1 between 2001 and 2015.[19,23,49,60] In China, by averaging the first, third, and fourth quarters of 2003, the second-quarter loss was estimated as a 3.1% decrease in GDP for the quarter, resulting an estimated loss of USD 12.3–28.4 billion for the whole year.[30] Furthermore, changes in other indices such as credit default swap,[32] consumer price index (CPI),[32,41]

Table 1: Study characteristics

Study characteristic (total number of studies)	Description	Frequency (%)
Type of country study (*n*=62)	Single-country	47 (76)
	Multi-country	15 (24)
Income group (*n*=47) (based on single country study)	High-income economics	32 (68)
	Upper-middle income economics	13 (28)
	Lower-middle income economics	2 (4)
Region (*n*=47) (based on single country study)	East Asia and Pacific	15 (32)
	North America	12 (26)
	Europe and Central Asia	10 (21)
	Latin America and the Caribbean	8 (17)
	Middle East and North Africa	1 (2)
	South Asia	1 (2)
Disease name (*n*=62)	Influenza (seasonal/pandemic)	27 (44)
	SARS	10 (16)
	COVID-19	7 (11)
	H1N1	7 (11)
	MERS	4 (6)
	Avian influenza	3 (5)
	H7N9	2 (3)
	Equine influenza	1 (2)
	Swine influenza	1 (2)
Single country article (*n*=47)	USA	11 (23)
	Italy	9 (9)
	China	5 (11)
	UK	4 (9)
	Turkey	3 (6)
	Australia	2 (4)
	Mexico	2 (4)
	Republic of Korea	2 (4)
	Canada	1 (2)
	Switzerland	1 (2)
	Spain	1 (2)
	Singapore	1 (2)
	Saudi Arabia	1 (2)
	Hong Kong	1 (2)
	Taiwan	1 (2)
	Japan	1 (2)
	Norway	1 (2)
	Malaysia	1 (2)
	Peru	1 (2)
	Argentina	1 (2)
	Cambodia	1 (2)
	India	1 (2)
Study focus (*n*=62)	Human	57 (92)
	Not human	5 (8)
Date published (*n*=62)	2010-2020	41 (66)
	2001-2010	19 (31)
	1997-2000	2 (3)
Language (*n*=62)	English	62 (100)

SARS=Severe acute respiratory syndrome; COVID-19=Coronavirus disease 2019; MERS=Middle East respiratory syndrome

Table 2: Study scales

Category	Article references	Subcategory	Quantitative data	
			Scale	Articles info
Macroeconomic	[1,2,11-61]	Economic index	$	[30-32,41,42,44,48]
			%	[19,23,30,32,41,44,49,55,60]
			N	[32,41]
		Welfare and well-being	$	[27,30,40,43,48,53,59]
			%	[32,40,43,49,51,53]
			N	[31]
			D/H	[24]
		Productivity loss	$	[13,18,29,33,47,51,52,55,59,61]
			%	[14,15,21,29,31,32,39,43,45,47,49,52,58,59,61]
			N	[22,29,31,52]
			D/H	[14,15,24,47,49,52,59]
		Additional costs or burden	$	[2,13,18,28,29,35,41,42,47-50,55,57,61]
			%	[28,35,44,50]
		Projected economic impacts	$	[22,42,45,56,57]
			%	[19,22,45]
Health system cost	[2,11,13,15,16,18-22,24,26,28, 29,35,36,42,49,51,52,54,55, 59-65]	Hospital and clinics	$	[11,20,26,49,51,52,55]
		Drug, immunization, and medical equipment	$	[11,24,35,42,61,62,64]
			%	[35,42,49,51,61,62,64,65]
		Psychological status	-	-
		Insurance organization cost	$	[61]
			%	[2]
		Cost of disease	$	[11,13,16,18,20,24,26,29,49,51,52,55,61,63-65]
Industry	[22,23,26-28,30-32,36,38,40,4 1,44,45,48,53,56,66-70]	Tourism	$	[27,30,40,53,69]
			%	[40]
			N	[27,40,44,69]
		Aviation	$	[22]
			%	[22,27,53]
			N	[22]
		Metals and minerals	$	[68]
			%	[68]
		Agriculture and Farming	$	[28,40,41,69]
			%	[48,66]
Businesses and trade	[11,21,23,25,28,30-32,34,36,38 ,40,44,45,48,53,68,69,71]	Business loss	$	[28,48]
			%	[32,53,71]
		Trade loss	$	[69]
			%	[32,69]
Educational impact	[31,42,45,49,51,58,59,62]	Daycare absence or miss	$	[42]
			%	[51]
			N	[31,49]
			D/H	[49,51]

the Singapore Airlines deficit,[31] statutory reserve ratio,[44] Vietnam stock index,[37] stock indices/current account deficit,[32] economic confidence index,[32] producer and consumer surplus,[48] and quality-adjusted life-year loss[55] were reported.

On the other hand, welfare and well-being impacts were reported in 20 studies.[22,23,25-27,30-32,36,38,40,41,43,45,48,49,51,53,54,59,66] For instance the estimated welfare impact by avian influenza in Minnesota, USA, in 2019 was $13.6 million.[48] Furthermore, by considering revenue loss, SARS disease, in 2003, caused a decline in the average annual household income to $175.44, a 22.36% reduction in what was expected.[53] While, over the two seasons in 2008 and 2009, the swine flu pandemic accounted for 20% of total direct revenue loss in the United Kingdom, though the rest of 80% of the direct revenue loss was caused by economic crisis.[40] During the 2009 influenza A (H1N1) pandemic, 11% of households in Ushuaia (the wealthier city of Argentina) which lost workdays also reported lost work income, compared with 57% in Jujuy.[43]

Sixty-two percent of studies regarding welfare and well-being focused on accommodation, food, and beverage loss (13 from 21 studies).[22,23,26,27,30-32,36,38,43,45,53,54] The estimated effect of SARS on the Canadian accommodation and food service sector was $4.3 billion in 2003, while that of Australian losses due to the same disease in 2003–2004 was lower at $0.12 billion.[30] Moreover, impacts on travel[26,36,53] and transport[26,28,43,45,49,51] such as postponement of 37.9% trips[53] and spending costs for transportation between 14.5% and 17%[49,51] were reported.

Productivity loss was mentioned in around 50% of studies[13-16,18,19,21,22,24,27,29,31-33,36,38,39,43,45,47,49,51,52,55-61] in direct[18,27,29,33,38,47,49,55,61] and indirect[13-16,18,19,21,22,24,29,31,32,36,38,39,45,47,49,51,52,56-61] forms, by estimating criteria such as considering staff working environment, illness-related mortality, worker's absenteeism,[13-16,19,24,29,39,45,47,49,51,52,56,59,61] job loss,[21,22,31,32,36] wage loss,[18,21,31,59,60] work time[14,15,29,45,49,52,58] or work day,[13,24,29,32,43,47,49,51,52,57-59,61] and loss and shortage of workforce,[15,36,38,45] especially because of social distancing, closing of business or schools, or self-isolation. The annual value of productivity loss in the USA was about US$27 million.[55] In Toronto, direct productivity loss per life loss was at approximately $460,530 and per person quarantined $1140 in 2004[18] while per person direct productivity loss in 2006 in Singapore associated with staff working environment was reported between $296 and $1026.[33]

Considering indirect productivity lost, work absenteeism of patients and caregivers accounted for the majority of costs[14] which was reported in 13 studies. Furthermore, during 2005–2006 and 2008–2009 influenza season in the USA, 30% and 37% of patients had at least 1 day of influenza-related workplace absence, which its costs per case of influenza ranged from $279.5 to $226.3, respectively.[29] The influenza-related absenteeism during three epidemic periods (2010–2013) was quantified as totaling more than 11,000 days/year among Italian health-care workers.[15]

Overall, during pandemics, sickness absence from work and job loss increased from 8% to 37%[29,39,52] and from 13% to 14%,[21,32] respectively. In contrast, the number of employees working in one industry to the whole decreased between 2600 and 310,000.[22,31] Wage loss percentage was from 18% to 89.6%[21,31,59] and wage lost per life year per worker was between $6,433 and $30,702.[18,59] Moreover, about 9%–50% of employees have work time off,[14,49,52,58] and even about 173,000 sick leaves due to influenza per year[52] were reported. Furthermore, by considering workday loss, about 10%–90% of households lost workdays[43,52,58,61] which was about <1–9079 working days lost.[24,47,49,59] The average lost earnings was between $38.7 and $159.2.[13,51] Moreover, a total of 793,000 ($231 million productivity loss) working days lost,[52] of which 98,800 days ($29 million productivity loss) was related to the parents taking care of sick children.[52]

In total, 32 studies mentioned additional costs or burden related to the economic impacts such as administrative costs[2,11-13,16-20,22,23,26,28,30,32,34-36,39-43,46,47,49-51,54-57,61] and economic consequences or projected economic impacts.[19,22,42,45,46,56,57] Paying attention to the managing cost of pandemic, according to the first quarter report of Ontario finances for financial year 2003–2004, the provincial government spent $12 million on SARS-related administrative costs as establishment of a SARS Assistance Office and to protect the jobs of those who were quarantined.[18] Whereas, in 2020 in the United States, the Coronavirus Aid, Relief, and Economic Security Act provides $100B to hospitals as a result of COVID-19 financial burden.[2]

According to the studies, the economic impact of respiratory disease pandemics was between $13.6 million and $166.5 billion[13,28,35,41,48,55,57] and the economic burden was around 4% and 80%.[28,35,44] In addition, the estimated economic impact of a pandemics almost depends on the availability of vaccination and vaccination strategies. For example, in 1999, the estimated economic impact of an influenza pandemic without large-scale immunization was between $71.3 and $166.5 billion in the USA (excluding disruptions to commerce and society), of which, at any given attack rate, loss of life accounted for approximately 83% of all economic losses.[35] Moreover, in 2006, as a result of influenza pandemic, the economic impact on Turkish economy depending on the vaccination strategies was between 1.364 billion and 2.687 billion dollars.[57]

Seven reviewed studies that emphasized on projected economic impacts according to the GDP rate,[19,22,42,45,46,56,57] were divided in two categories: projected cost[42,49,55] and hypothetical scenario's costs.[19,22,42,45,46,56,57]. It was reported that the annual projected cost of respiratory disease pandemics to the society was from $59 billion to $87 billion.[42,49,55] In studies regarding scenarios, reported data were according to the attack rate and vaccination percentage, depended on combining disease, school closures, prophylactic absenteeism, and vaccination strategies. This caused reductions in GDP by disease scenario between 0.02% and 29.5%[19,22,52] or a fall in CPI from 0.28% to 1.5%.[45] Furthermore, the reported economic impact of pandemic respiratory diseases was between $350 million and just under $600 billion.[22,42,45,56,57] In the United States to provide a national aggregate perspective with aggregate economic models by a projected GDP, a loss of $595 billion was estimated in a 2008 study.[42] Furthermore, the indirect cost of pandemic influenza (workforce loss) in Turkey in 2006 for the minimum scenario (with 100% vaccination percentage and 30% attack rate) with affected 6600000 workforce (persons) was estimated to be $356 million.[57]

Health system impacts

According to the reported data, health system costs were reported in 29 studies. Analysis of these costs contributes to understanding of underlying factors impacting the overall cost of respiratory diseases in our classification, including hospital and clinics,[2,11,16,20,26,29,35,42,49,51,52,55,60,61,63] drug,[11,16,24,42,49,51,52,61,64] equipment[21,62] and immunization,[28,35,42,61,65] Medicare,[2,11,61] psychological status,[15,19,22,24,28,36,54,59] and the cost of disease.[11,13,16,18,20,24,26,29,49,51,52,55,61,63-65]

Hospitalization (inpatient) cost was reported in 14 studies. It is shown that every participant with confirmed influenza illness paid between $171 and $9043,[11,49] and the total treatment cost associated with hospitalization for SARS, flu, and H7N9 costs was between $15 million to $41.7 million in China, Norway, and the USA between 2009 and 2017.[20,26,52,55] The provided information on outpatient costs for influenza illness was between $5 and 197 per person in low- and upper-middle-income countries.[11,51] Private clinic service mean cost (in the 2005/2006 season and 2006/2007 seasons) was calculated to be $683,000, contributing to a total outpatient cost of $4 million in Norway.[52]

Considering medication equipment, and immunization costs; medication costs were between $5 and $91.48,[11,24,61] while the percentage of the family's costs resulting from medication costs was between 22% and 73.4%.[49,51,61] Moreover, nearly 22%–74% of the families' cost was due to different drug consumption.[49,51,61] It was reported that consumer's self-treating costs (over-the-counter) were about 33%–90.3%[51,64] which has caused $102 billion annual savings for the US health-care system.[64] Hand hygiene compliance rates increased before and during disease from 73% to 88%,[62] but the monthly added cost for infection control items was around $16400.[62] Furthermore, 3%–45% of costs were due to the vaccination[61,65] and a net saving to society per vaccine was $21,[35] while a net loss per vaccine if persons not at high risk for complications are vaccinated at gross attack rates of 25% was at $62.[35] The prevaccination cost per capita was $140[42] and this strategy reduces number of cases by 48%–60%.[35,42] Full TAP cost per capita was $127,[42] but adding school closure to full targeted antiviral prophylaxis or prevaccination increases total cost to society per capita at approximately $2700.[42] Medicare inpatient payment rates increased by 20%[2] and 70% of respondents asserted that they were willing to spend up to $35.8 out-of-pocket for an effective intervention against influenza or I-influenza and influenza-like syndromes.[61] Psychological impacts of respiratory diseases were reported in 8 studies.[15,19,22,24,28,36,54,59]

Data on the cost of illness were presented in 16 studies[11,13,16,18,20,24,26,29,49,51,52,55,61,63-65] that were categorized in cost per episode,[11,13,16,24,51,61,63,65] cost per person,[11,29,49] the annual cost,[16,52,55,64,65] and total cost of pandemics.[16,18,20,26,52] Full estimates of the cost per episode were addressed in 8 studies by <$500,[11,13,16,24,51,61,63,65] of which the lowest proportion ranged from average 34 surveyed studies over the time period of 1950–2013 in low- and middle-income countries at $5,[11] and the highest at $491.3 during 2010 in Australia.[24] The mean per patient total influenza health-care costs in the reviewed studies was between $3 and $9043,[11,29,49] of which from 2004–2005 to 2008 in the USA, it was approximately 1.5 times more than median hospitalizations costs in Peru during June–December 2009–2010 (between $254 and $363 for the US, compared with $171 for Peru).[29,49] In the United States, the mean annual direct and indirect cost of influenza was reported in the range between $200 million and $11 billion.[55,64,65] The total cost of influenza per year was from $2.8 million to $24 billion,[16,18,20,26,52] for example, in Peru (2009/2010) and Norway (2005/2006), it was at about $80 million and $250 million, respectively.[49,52]

Five studies were reported on the costs of pandemics, of which, according to the first quarter report of Ontario Finances for 2003–2004, the direct administrative cost of the epidemic SARS was $12 million,[18] while the total treatment cost of SARS in Beijing (China) for 2521 cases was $4.8 million.[26] The total direct medical cost of H7N9 associated with hospitalization across China in 2015 was about US$ 6 932 408,[20] while that of influenza varied between over $800 million in Norway[52] and $24.3 billion in Italy from 1999 to 2008.[16]

Impact on industry

The impact of respiratory disease pandemics on industries was discussed in four main categories in 26 studies: tourism,[26,27,30-32,36,40,44,45,53,56,69,70] aviation,[22,26,27,30,31,53,68] metals and mining,[23,68] and agriculture and farming.[23,28,32,38,40,41,48,66,67,69] The impacts on agriculture and farming was divided in two subcategories i.e. the impacts on agriculture, forestry and fishing,[23,32,38] and impacts on animals (such as consumption, price, etc.).[28,40,41,48,66,67,69] Tourism industry witnessed a reduction of noncitizen visitors from 1 million to 30 million[27,40,44,69] and tourism revenue loss from $15.02 million to $3.5 billion;[27,30,40,53,69] for example, H1N1 caused an estimated revenue loss of $2.8 billion because that 1 million people never arrived in Mexico over a 5-month period in 2009.[69] Furthermore, in the Republic of Korea, during June–September 2015, the MERS outbreak was correlated with a reduction of 2.1 million noncitizen visitors corresponding with $2.6 billion in tourism loss for this country.[27] Moreover, global pandemic COVID-19 which influenced on the universal economy, trade, and tourism caused the cancellation of 30 million tourist arrivals to visit Malaysia 2020 campaign.[44]

Furthermore, Malaysian tourism industry bore $1.7 billion estimated losses by averaging 2002–2004 values, while that of Singapore hotels' loss was lower at approximately $0.2 billion.[30] Moreover, between 2005 and 2008, the SARS outbreak resulted in tourism loss between $15.02 million and $3.5 billion in China.[30,53] In the case of the economic crisis of swine flu in 2008, the source markets were responsible for the greatest reductions in U.K. tourism receipts in the United States, Germany, Ireland, and Russia by $1061.4 million, $629.8 million, $244.8 million, and $202.3 million, respectively.[40]

Considering aviation changes, totally 141 airports were collected from the OpenSky Network which caused a 4.1% impact on GDP and travel ban loss was about $3.3 billion as a result of COVID-19 in 2020.[22] Furthermore, 16% of the total number of actual noncitizen visitor arrivals (2.1 million) decreased in 2015 MERS Republic of Korea outbreak,[27] while the SARS disease in 2003 caused 70.0% of foreigners and 31.0% of overseas Chinese arrivals decreased.[53]

Regarding the mining and metal sector changes, it was shown that, across March and April 2020, a dramatic contraction in demand as industrial production and construction has caused dramatic falls in the prices of a range of metals such as aluminum, copper, lead, nickel, and zinc, by about 15%, 14%, 10%, 11%, and 6% (US $/lb), respectively, and for Gold by 2% reduction (US$/oz.).[68]

Taking into account agriculture and farming, by focusing on the consumption changes, seven studies (11%) focused on animal (Chicken,[1,41,48,66] Horse,[28] Swine,[40] Pork,[41,69] and Poultry,[1,41,48,67]) economic impact. Among the various source markets, the swine flu-related losses in 2009 season from the United States and Spain were estimated at $160 million and $230 million loss, respectively,[40] while that of horse-related income loss because of equine flu between August and December 2007 was higher at about $520 million in both New South Wales and Queensland.[28] China's poultry industry suffered a loss of more than $6.2 billion as a result of H7N9 outbreak.[41] Furthermore, the 2009 pork trade balance showed at around $30 million deficit for Mexico.[69] The total reduction in the number of shell eggs supplied in Turkey[48] and protein consumption in China was dramatic.[66] Furthermore, in China, many places closed their live poultry trading, while the SARS (2003) and H7N9 (2013) outbreak resulted in serious economic losses to farmers in China.[41] Avian influenza in Cambodia, Vietnam, and Thailand affected consumer-market reactions and the entire industry,[67] while H1N1 caused sectorial impacts on the South African by declining in forestry.[23]

Impacts on business and trade

Business impacts of respiratory disease in the field of supply and demand were reported in about 20% of studies. The severity of this phenomena was categorized in business loss[11,21,23,25,28,30-32,34,36,40,44,45,48,53,68,71] and trade loss[23,32,38,44,45,69] and was explained in the studies by using various impacts on demand,[23,25,31,36,40,45,68] supply,[23,25,31,32] markets,[21,30,32,34,40,44,45,53] production,[23,30,32,71] investment,[11,30,34,45] trade,[32,38,44] import,[23,32,69] and export.[23,32,45,69] These phenomena were caused a downstream to the supply chain;[25] increase in the need for medical supplies;[36] loss in household demand (consumption); export loss in response to the lost productivity which was resulted from labor supply shock;[23,31] negative impact on the 14 markets' demand;[40] a business fall related to the tourism demand;[31] a dramatic contraction in demand as industrial production and construction;[68] and having severe adverse effects on the employees, customers, supply chains, and financial markets, which, in brief, were caused a global economic recession.[32]

Evidence on broader impact of influenza in low- and middle-income countries included impact on the wider national economy, security dimension, medical insurance policy, legal frameworks, distributional impact, and investment flows between 1950 and 2013.[11,34] Furthermore, in reviewed studies, among 29 countries, the largest economic impact of SARS in 2008 was related to overall GDP, investment (inward and outward), and retail sales.[30]

Educational impacts

Data showed that educational impacts in 8 studies mainly focusing on daycare absence or miss[49,51] and missing schoolwork,[59] because of school closures[42,43,45,58,59] which caused parents, reported workplace absenteeism, wage loss, and the need to pay for alternative childcare during the closures.[43,45,59] The most common inconveniences for families with pupils and kindergartners were missing schoolwork (averaged from 1.9 to 3 days[49,51]) and fear of getting infection, respectively;[59] school closure dramatically increases the cost of families in the United States to $840 billion, reflecting the broader economic impact on parents missing work to care for their children at home.[42]

DISCUSSION

The reviewed studies show that economic impact of acute respiratory disease encompasses multiple dimensions. These include direct and indirect costs in various areas of micro- and macroeconomics. In a way, this issue directly affects the costs of providing and receiving health services, disease management, industries (aviation industry, tourism, agriculture and livestock, etc.), trade and education, and indirectly has a broader impact on the wider economy due to the productivity losses.

Although it is usually mentioned that the greatest economic cost of seasonal and pandemic influenza was due to death,[35,55] there were other impacts such as a permanent loss to the economy,[43] adverse impact on production,[32] and posing a great burden to the overall hospital budget.[31] For example, social and economic burden of influenza in low- and middle-income countries in 2015 led to a permanent shift in the world and its politics, especially in health, security, trade, employment, agriculture, manufacturing good production, and science policies.[32] It is while the COVID-19 global pandemic may well become the most defining economic and social event in decades.[68] Moreover, social distancing, self-isolation, and

travel restrictions forced a decrease in the workforce across all economic sectors and caused many jobs to be lost.[36]

Countries in Asia[34] and low-income countries[23] with lower socioeconomic status[43] experienced more negative abnormal returns as compared to other countries, particularly among the poorest families and those hospitalized.[49] In the long term, this situation will bring deterioration in human capital that has a great impact on the economic development of countries.[32]

In addition to its social impact, acute respiratory diseases also have a significant economic impact, including direct costs (e.g., drug consumption and hospitalizations), indirect costs (such as absenteeism and reduced productivity), and intangible costs (e.g., pain, suffering, and impaired quality of life).[16] Furthermore, during pandemics, the need for medical supplies (the cost of masks, soaps, and gels and lack of availability of masks, water, and soap) has significantly increased[21,36] and available tests to document influenza are either too expensive, too inaccurate, or too time consuming.[60]

This review highlights the need for standardization of the estimations. We observed that basic components of case management costs – economic impact – were not consistently presented across the studies reviewed: only seven studies from Australia, Italy, the United States, China, and Turkey provided data on this component, including three on seasonal and pandemic influenza (Italy[13] and the United States[35,55]), one on equine influenza (Australia[28]), one on avian influenza (Minnesota, USA[49]), and one on SARS and H7N9 (China)[41] that gave overall estimates of total direct costs. Other studies included information either on economic burden or other indirect economic dimensions.

Another example is the inconsistency in estimating and reporting productivity loss. While most studies used indirect productivity loss by calculating the rate of absenteeism, job loss, work time lost, wage loss, or work day loss, only seven studies presented information on direct productivity loss. Furthermore, five studies provided absenteeism estimates in days,[14,15,47,49,52] two study on percentage,[29,39,52] one in monetary values only,[29] ten studies mentioned qualitatively,[13,16,19,24,39,45,51,56,59,61] and the remainder did not consider them at all.

One challenge is that most studies did not present statistically meaningful measures of uncertainty around estimates; they mainly gave single-point estimates or at most minimum–maximum ranges. In addition, some studies focused on descriptive information and considered economic burden instead of economic monetary values.

Limitations

First, the lack of sufficient evidence related to acute respiratory diseases in the Middle East, North Africa, and South Asia made it impossible to better estimate or judge the economic effects of these countries. Second, the limited access to nonhuman studies made it impossible to compare the economic effects of this field. Finally, it can be stated that the heterogeneity of the methods used to estimate the cost components limited the data synthesis and challenged the consensus, which can be examined by interested researchers.

CONCLUSION

The economic impact of acute respiratory disease pandemics encompasses dimensions such as the costs of providing and receiving health services, disease management, industries, trade, education, and indirect costs due to productivity losses as well as some evidence on broader determinants to the wider economy. Indeed, the indirect costs greatly exceeding direct costs of acute respiratory diseases impose a heavy economic impact on families, industries, and societies. The paper holds important lessons for estimating the economic impact of future pandemics and measures to control or prevent them. Heterogeneity of methods used to estimate cost components makes data synthesis challenging. Therefore, there is a strong need for standardizing research, data collection, and evaluation methods for both direct and indirect cost components. We suggest that further work is needed to develop a more comprehensive macroeconomic model able to more accurately estimate the relative economic cost and impacts of the acute respiratory disease pandemics. Our findings on the estimates and determinants of economic impacts from acute respiratory diseases highlight the importance and feasibility of an interdisciplinary (epidemiology/health economics) approach to such research. Understanding these impacts, and analyzing their significance, and the role it plays in wider economic development is a crucial task for academic research. The outcomes of this research could be used by decision-makers to predict the operative and long-term economic impacts of acute respiratory disease pandemics.

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Conflicts of interest

There are no conflicts of interest.

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