



Pharmaco Economics Analysis of COVID-19 Vaccines in Ukraine

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Authors' contributions

This work was carried out in collaboration among all authors. Author TYV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SVI, KT and TBY managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate pharmacoconomics for the vaccination of COVID-19 vaccine and analyze the cost-effectiveness for the vaccine in Ukraine.

Study design: we have analyzed using models for the economics of coronavirus vaccine.

Place and duration of study: Sample: population of Ukraine, data used from the official website of Ministry of Health, Ukraine. April - May 2021

Methodology: We have used the transmission model to analyze the vaccine strategy. Data were collected from official sources. We structured an age group model for evaluating high transmitters.

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Four strategies were organized and analyzed for analyzing the cost-effective strategy vaccination for everyone, no vaccination, and vaccination for old age only, high transmitters' vaccination.

Results: we have analyzed country specific cost-effective strategy for Ukraine depends upon the pandemic and economics of the country. Vaccinating older people was found to be the economically effective for Ukraine. In these study influences of discount rate analysis on QALY in Ukraine was done. When we vaccinate, high transmitters' ratio was found to be 8.8% higher than for the elderly. This analysis suggests that vaccinating first the elderly group would not be so cost-effective. While doubling the cost for the vaccine, if the vaccine is available early with the scenario of pre-existing immunity has shifted cost-effectiveness for high transmitters than for the elderly in Ukraine

Conclusion: we conclude from our pharmacoeconomic research study that cost effective analysis depends on pandemic and vaccinating elderly would be effective economically.

Keywords: Pharmacoeconomic analysis; coronavirus; COVID-19 pandemic; vaccine strategy.

1. INTRODUCTION

Corona virus disease identified as an acute respiratory syndrome, which is known as COVID-19. The significant risk group includes the elderly (ages >65) and people with chronic illness. Coronavirus has imposed harmful effects on health and economic values; an alarming situation is created in Europe. This pandemic has caused a crisis in the global economy; the government has to face challenges in taking measures to improve or prevent this situation [1]. The upcoming health challenges have caused pharmaceutical companies to develop vaccines for coronavirus disease [2]. Its development itself is a challenge for the manufacturing companies and its clinical trials and balancing stakeholder's expectation in a pandemic.

COVID-19 is declared as global pandemic in relation to health and economic emergencies. Almost mortality has reached more than 2 million of the global population and in addition to this in poor countries, the mortality has reached to more than 140 million global population. Emergency condition rises; WHO (world health organization) and FDA (food and drug authority) has given permission and released certain principles to start vaccine development. In addition public health awareness programmes are also started as illiteracy doubles the chances of transmission of the disease. During the COVID-19 pandemic and now, when the vaccine is in the market access, it is potentially needed of the hour to focus on vaccine economics [1]. Currently, there are rare researches carried out on the pharmacoeconomics analysis for the vaccine at this peak time of COVID-19. Soon, when more population is vaccinated, there will be more demand to scrutinize the economics of country-specific data [3]. The high reluctance of the economy for Ukraine, in addition to the low

incomes of its entities, the overall tense macroeconomic policies imposed recently, and the economics unresolved structural problems have direct effects on the speed and depth of the indirect shocks that directly penetrate the Ukrainian economy [4]. Preventive measures in Ukraine, such as social distancing, closing borders, and slow economic activity with destabilizing marketing, ave together perturbed turbulence in the Ukraine financial market [4]. Here in this paper, we focus on the "value in health," focusing on health economics with the COVID-19 vaccine.

Pharmacoeconomic analysis helps in decision-making, which will significantly impact the country's economy. The most remarkable example of pharmacoeconomic analysis is of UK – NICE (National Institute for Health and Care Excellence), where they do decision making by performing researches for QALY(Quality Adjusted Life Years), or clinical trials and modeling wherever necessary [5]. Pharmacoeconomic studies for COVID-19 vaccine involves the vaccine process and its safety and efficacy. The WHO has launched the COVAX facility, the vaccine alliance, the Gavi, and the Coalition for Epidemic Preparedness Innovations, enabling countries to pool their purchasing power. All around the globe, Nearly 141 countries started the vaccination process. The vaccination process involves various stages, starting from the development stage to the marketing stage. External funding is required to continue care for the COVID-19 patients [6].

The Ministry of the health of Ukraine, the public health center, together with support of WHO, has proposed vaccination strategies to immunize population. According to the World Bank official data, \$ 90 million loan for Ukraine COVID-19

vaccination. World-famous developers have approved four vaccines in Ukraine: AstraZeneca (Covishield), Sinovac Biotech, Pfizer-BioNTech, and Novavax. Approx 43 million doses have been purchased by Ukrainian government. Due to the widespread pandemic, the demand has been increased enormously for vaccination to reduce the mortality and morbidity rates. To set up a vaccine prioritization in a country for reducing the death rate and transmission rate, the pharmacoeconomic analysis helps in decision making [7]. This paper includes pharmaco-economic research for COVID-19 vaccines in Ukraine. This cost analysis research is scarce, and yet no research has been done in Ukraine. Research identifies and compares the costs, risks, and benefits of COVID-19 vaccine strategies in Ukraine [5].

2. METHODOLOGY

Here we analyze the pharmacoeconomic factors for the coronavirus vaccine in Ukraine, using an age-structured model for transmission of COVID-19 pandemic by examining health care cost and consumption involved for resources utilized in healthcare system specific to Ukraine [8]. This transmission model helps analyze using demographic data, low and high-risk groups, and contact patterns all elements used for studying risk contacts.

2.1 Model Used

2.1.1 A transmission model

We have used demographic analysis using an age-structured model showing coronavirus spread in a population [7]. In an age-structured model, the population was divided into six groups first three were for the children; age group 0-4 years classified as preschool age. 5-12 years classified as a primary school group, 13-19 years

classified as a secondary school group, then young adults 20-39 years, Then the remaining adults, Ages between 40–64 years and last elderly, Ages >65 years. These groups were further organized by the infectious group's infectious classification, an infected group without being infectious, infected with the infectious group, recovered or dead. A report stated that mild respiratory symptoms were developed 5-6 days after infection; ranges from 1 to 14 days [9]. Another report states that the median time averages three days before the onset of symptoms; ranges from 24 hrs to 24 days [9].

2.1.1.1 Social contact patterns

Social contact patterns are directly linked to a high transmission rate. School-going children have more social contact patterns each day. Here we have evaluated age-structured social contact patterns from data on self-reported social contact rates from the Ministry of the health of Ukraine.

2.1.1.2 Demographic data

According to age size, the official sources have up-to-date population data such as Euro stat: the official census and World Bank for population statistics (Table A).

2.1.1.3 Social contact patterns

Social contact pattern is a key element to transmission model as it enhances the predictive accuracy and investigations for the effect of interventions which are targeted at specific settings such as workplaces, schools or homes. Some researches show that family size is also related to social

Table A. Demographic data Ukraine

Variables	0-4 years	5-12 years	13-19 years	20-39 years	40-64 years	>65 years
Ukraine						
% population	2.5%	3.8%	5.1%	8.2%	15%	7.15%
% population of high risk groups	0.006	0.020	0.014	0.412	0.754	1
Remaining life years	77.6	71.3	63.8	50.6	29.6	8.1

contact pattern and increasing the risk of infection transmission [10]. Social contact patterns directly cause a high transmission rate. School-going children have more social contact patterns each day. Here we have evaluated age-structured social contact patterns from data on self-reported social contact rates from the Ministry of the health of Ukraine.

2.1.1.4 Risk groups: low and high

Each individual is at risk of developing complications from the COVID-19 infection. There is more data on the evidence which suggests that old age group ages >65, as they are more prone to infectious diseases because 90% of old age group are with co morbid diseases such as diabetes mellitus, hypertension, respiratory diseases and so on. Almost 80% of deaths were of older age group (>65 years). The overall average fatality rate calculated is approx 4% and more than 10% for ages above 60 years. All these researches indicate that ages above 60 years are more prone or are at high risk. Here we have divided the age-structured group further into low and high-risk groups of developing severe complications. Immuno compromised patients, elderly with co-morbid diseases or patients with respiratory disease, are grouped into high-risk groups.

2.1.1.5 Vaccination efficacy

We have assumed vaccine to be imperfect following "all or nothing" that is, either it will provide all perfect protection from the disease, or it will not provide any protection it will fail. Studies are limited, but we have divided here people who were vaccinated compared to those who were not vaccinated. Vaccinated people have a 60 - 70% low risk of developing an infection than those who are not vaccinated. Also, vaccinated people with symptoms have a 40% low risk of hospitalization or developing severe symptoms than those who are not vaccinated. The vaccine used was Pfizer/ BioTech vaccine.

2.2 Analysis of Vaccine Strategies in Various Scenarios

2.2.1 Strategies for vaccination

We have analyzed different vaccine strategies, vaccination for everyone, no immunization, vaccination for old age only, vaccination for high transmitters (school-going period from 5 to 15

years). It is observed that not the whole population group eligible for vaccination would be vaccinated. We have assumed 90% to be vaccinated for the selected group as vaccination is not registered for use below six months of age, so we have decreased the 0 to 4 years group rate.

2.2.2 Pandemic strategies

To evaluate pandemic strategies, we have developed four different strategies, as different countries face different situations. First, pre-vaccination is two weeks before the peak wave of coronavirus, and post-vaccination is during the peak wave of the coronavirus.

The novel coronavirus strain is susceptible to the whole population. When the vaccination process starts, it is assumed as no immunity stage for the population. Retrospective studies carried out in the UK and US showed that some populations had pre-existing immunity that cross-reactive antibodies were found irrespective of COVID-19 infection, i.e., those individuals were never infected.

2.3 Pharmacoeconomic Analysis

2.3.1 Cost-effectiveness

When different health care interventions are not expected to give the same outcomes, both the variables costs and the consequences of the options should be assessed. The analysis is done by cost-effectiveness analysis; prices are compared with results calculated in natural units. We have studies cost-effectiveness in terms of QALY (quality-adjusted life years), costs per QALY were evaluated, and the incremental cost-effectiveness ratio of each specific strategy was compared with a non-intervention strategy.

2.3.2 Utilization of Healthcare resources

We have analyzed the healthcare resource utilization. Almost 60% of individuals infected with COVID-19 will develop symptoms, whereas others are infected but asymptomatic. Only 25% seek medical help (symptomatic infected patients). Several healthcare services were used in calculating the data: hospital visits to visit a general practitioner, over-the-counter medication, prescription drugs. 80 % of patients visiting the hospital were admitted inwards, and rest, 20 % were admitted to the ICU [11].

2.3.3 Losses in life years and quality of life

We have analyzed the quality of life years and life years lost due to the pandemic COVID-19, based on the disease burden estimated for Ukraine. Three scenarios were studied first, no exposure; second, moderate exposure; and last, severe exposure; for analysis of public health burden in terms of loss of QALY. QALY loss per person was 6-13 years per person [12]. QALY loss ranges from 2295 – 4525 QALY for Ukraine; this is estimated annual coronavirus disease-associated also depending on co morbidities [9].

2.3.4 Analysis of Costs

Our study researches Ukraine, so we have collected data from official data from the Ministry of the health of Ukraine and percentages of cases of the respiratory syndrome-like disease. These were the direct costs of patients who developed symptoms. These were the estimated costs of medical care, medical costs, and

admission costs. Some variation might be expected, but it is not so large, which would cause a difference in the data. We have estimated a two-dose schedule for vaccination costs.

Cost losses should also be a cost-effectiveness analysis. According to UK guidelines, all essential items should be included in the analysis, and the inclusion of production losses is not always required.

Research data shows that nearly a third of people in need of hospitalization could not afford its cost and could not use the resource. Age inequality (ages >60 years were found to 40%, whereas ages from 45 to 69 years were 35%) and income inequality. This data was collected from the health index Ukraine survey 2016 [13]. This was used as a proxy for our study.

Table B. Vaccination strategies: percentage of the population vaccinated

Scenarios	0-4	5-12	13-19	20-39	40-64	>65
No vaccination	0	0	0	0	0	0
Everyone	65	90	90	90	90	90
Ages>65 years	0	0	0	0	0	90
Ages 5-15 years	0	90	90	0	0	0

Table C. Pandemic strategies for COVID-19

Four scenarios	Ages: 0-4 (years)	5-12	13-19	20-39	40-64	>65
Prevaccination						
No immunity	0	0	0	0	0	0
Pre existing immunity	0	15	10	5.3	0	0
Post-vaccination						
No immunity	0	0	0	0	0	0
Pre existing immunity	0	15	10	5.3	0	0

Table D. Healthcare resources cost analysis

Variables	Probability for the usage of resources	The unit cost of each resource
Cost of vaccination (its administration)	2 doses	16
Symptomatic patient's visit to the hospital	25%	9.7
Prescription antibiotics	17.5%	20.5
OTC medication	80%	6
Hospital stays		4075
Ages 20-40 production losses		233
Ages 40-65 production losses		233

2.4 Sensitivity Analysis

We have used five variables for sensitivity analysis of health services economic outcome for uncertainty measurements about precise value for two variables that are economical and epidemic. The first variable we have used in our study is the cost utilized per vaccine. JSClekhim pharma is officially granted permission to develop the vaccine; Sinovac Biotech is an officially authorized vaccine in Ukraine. This vaccine costs 504 UAH per dose. The total estimated dose required is 1,913,316 doses. Another variable was the discount rate for incremental QALY. We have assumed no discount rates for the life years as it would create a difference in the life years assessed. The third variable we used is the reproduction ratio, in which we have described the infectious period and transmissibility. COVID-19 pandemic reproduction ratio has been found in the Ministry of Ukraine's official site to be 1.7; we have assumed low (1.4) and high (1.8) transmissibility ratio [14]. Vaccination coverage has been used as a fourth variable. Using Table B, we have reduced the values to half from the base values. Pre-existing immunity level was the last key variable used here. Using Table C, we have increased half values from the base values in the analysis. All together, these variables will cover the pandemics.

3. RESULTS

We have evaluated the pharmacoeconomics of COVID-19 vaccination by analyzing different strategies. Table D has been generated to show direct healthcare costs, and indirect healthcare costs, and the QALY gained. The most cost-effective strategy for Ukraine depends upon the pandemic as well as the economics of the country. Vaccinating older adults was found to be cost-effective as they represent a high transmitting group for Ukraine. When we vaccinate and evaluate the QALY losses, the high transmitter's ratio was 8.8% higher than for the elderly. This analysis suggests that vaccinating first the elderly group would not be so cost-effective. While doubling the cost for the vaccine, pre-existing immunity and another variable that is early availability of this vaccine have shifted cost-effectiveness for high transmitters than for the elderly in Ukraine. We have also compared sensitivity analysis; various scenarios resulted in no cost-effective strategy [15]. The high cost of the vaccine with no immunity has added to the costs of healthcare

services, which is not found to be cost-effective. The results showed that the phamaco economics of vaccination depends on corona virus disease pandemic (C. Y. Liu 2021).

4. DISCUSSION

We have analyzed the available data which suggest that the vaccine for COVID-19 meeting the standards of WHO and FDA has the potential to be good value for money. Here the model considers only the benefits to those individuals who are vaccinated and direct health care system costs. Vaccination strategy for elderly over age 65 appears to be cost effective because of high cost and incidence of ICU care and ventilation. The results are consistent with this pharmacoeconomic analysis that found vaccination (\$100/course; 90% efficacy) to be cost effective overall considering societal costs [16]. The attack rate for the year following the launch of vaccine is one of the largest influencers. Current models used have predicted mortality only for several months into the future, as policy and individual behavior changes may affect the course of disease such that long term estimation are highly uncertain.

Economic analyses are now the most fundamental analysis required for the healthcare system in general and pharmaceuticals. These economic analyses are done to help in the allocation of scarce healthcare resources. These analyses should be performed with proper care and official data. This paper outlines the pharmacoeconomic analysis of the COVID-19 vaccine for Ukraine. We have used official data of Ukraine from the Ministry of health online portal of Ukraine. COVID-19 pandemic has disrupted the Ukraine economy and begins to spread globally. The sudden evolution of this respiratory disease and its high economic impacts are usually uncertain, making a bulk of formulation of appropriate macroeconomic policy responses the most challenging [3]. Some papers have researched and found out that there is a increase in demand of vaccine uptake in all scenarios, which will directly affect the scarce supply of vaccine, so it is the need of the hour to analyze targeted vaccine use [4,7]. Vaccine hesitancy in most of the population and inequity in the access and distribution of vaccination results in a patchy uptake. A fundamental method for allocation of supply which is limited, should be made with age-based targeting. Most vaccines are effective as post-exposure prophylaxis (PEP), for example, hepatitis A,

measles, and smallpox. As coronavirus has a long incubation period which suggests that COVID-19 vaccines might work as PEP [17]. Sandman found out that if the vaccination program is not started immediately, then the outcomes may become worse. A slow distribution and access will also lead to adverse economic and health effects than rapid uptake [18].

The present study is involved in the first analysis, which focuses on the pharmaco-economic analysis for the interventions against COVID-19. We have analyzed 18 lessons for the pharmaco-economics of COVID-19 vaccination strategies. These researches had good quality and are all recent studies [19]. We have analyzed pharmaco-economics of the vaccination strategy for Ukraine specifically. Here we have used four different strategies and organized them in different scenarios to study the effective method in economics; that is, we have evaluated the cost of healthcare resources for analyzing the best strategy. The most cost-effective strategy was different for different scenarios; that is, it depends on the pandemic. When we study the technique of vaccine availability was late in the pandemic, the strategy of vaccinating the elderly without immunity was found to be the most cost-effective. When pandemic was known early in the pandemic, vaccinating young people who are high transmitters was the most cost-effective. When we compare incremental cost per QALY gained, almost all scenarios were found to be cost-effective. The vaccination strategy for the whole population was sub-optimally effective, as it depends on the pandemic and the location. We have evaluated demographics on the vaccination strategies for Ukraine specifically. These evaluations impose stress to analyze country-wise different vaccination strategies to be the most effective methods in terms of pharmaco-economics.

5. CONCLUSION

The overall pandemic situation for the Ukrainian economy demands immediate actions for supporting population demand and supplies by monetary and fiscal policies. It is necessary to take strict measures to overcome the critical condition faced by the country's economy. To manage the economy, the government has to take potentially critical steps for decision-making. Identify various methods to cope up with the pandemic situation.

We have analyzed by our research study that effective method depends on different variables which are country-specific. Here in the analysis for Ukraine, we analyzed four strategies; not vaccinating was found to be the worst strategy; vaccinating young adults was cost-effective. This strategy would have exceptions depending on the availability of vaccine and time; before the peak times of the pandemic and in addition to the scenario of pre-existing immunity occurs. At the same time, vaccinating the elderly was the most cost-effective method. Country-specific data should be analyzed at the time of pandemic to investigate the most effective manner for the vaccination program. In conclusion, vaccinating the elderly would be the best strategy. Realizing the logistical challenges of COVID-19 vaccine to the entire population to respond effectively to this pandemic, we expect that investments done in research strategies based on economic effects could lead to positive consequences.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

All data was collected from official sources which are available to the public. The statistics data and coronavirus disease demographic data was collected from official ministry of health website of Ukraine.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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