A Comparative Analysis of COVID-19 Vaccine Distribution Efforts in India and Mongolia through Data Visualization

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Abstract

COVID-19 vaccine allocation efforts have posed challenges and offered opportunities to alleviate the ongoing pandemic. Nations have employed varying approaches for COVID-19 vaccine distribution; in particular, Mongolia and India have differed in approaches to vaccine allocation efforts. As of June 2021, Mongolia has vaccinated more than 60% of its population, whereas India has only vaccinated about 7.5%. This disparity highlights the need for the present study, which utilizes a mixed-method approach to examine the two countries' vaccine distribution strategies and COVID-19 containment policies from January to July 2021. The study has three major components: 1) policy analysis to highlight core differences between legislative approaches for containment, 2) dissemination of a survey to both nations to assess public perception of vaccine allocation and distribution efforts, and 3) mathematical vaccine modeling to analyze vaccination coverage in both countries. For the survey, 311 responses from India and 307 responses from Mongolia were analyzed using the statistical software JASP and SPSS. Results showed that Mongolian and Indian respondents had similar views regarding vaccine effectiveness, but that country and region influenced whether distance from a vaccination center was an obstacle for getting the vaccine. Policy analysis revealed key factors—such as early response policies, vaccine diplomacy, and resource allocation—had significant implications on the two nations' distribution efforts. Vaccine distribution pipeline modeling was based on the critical vaccination coverage fraction in each country and revealed that India would not have enough doses to achieve critical vaccination coverage at the current rate of administration. The results of this study effectively formulate a vaccination distribution structure and indicates viaros policies that current and future vaccine distribution efforts can follow.

Background

The COVID-19 pandemic has posed unprecedented challenges on a global scale (Cucinotta & Vanelli, 2020; WHO, 2020), with over 44 million COVID-19 cases and over 1.17 million recorded deaths between December 2019 and October 2020 (Mohamadian et al., 2021). Mongolia and India are two of these developing nations affected by COVID-19. Currently, India has the 2nd highest COVID-19 case count in the world with a record 31 million cases in total, while Mongolia is 90th with 0.14 million total cases (WHO, 2021). Between the two countries, India has witnessed the more devastating consequences of COVID-19, with daily cases reaching up to 400,000 (Roser et al., 2020). On the other hand, Mongolia was able to contain COVID-19 local transmission for around 10 months. Mongolia, with the help of the COVAX facility, has been highly successful in vaccinating 60% of its population (WHO, 2021). As of July 15, 2021, Mongolia has administered around 119.36 vaccine doses per 100 people (Ritchie et al., 2021).

Difficulties regarding vaccine allocation have been one of the major obstacle following the development of the COVID-19 vaccine. Countries either lacked the proper amount of vaccines for their citizens or the means of distributing those vaccines effectively. The lack of robust infrastructure and logistical solutions have been the major concerns that is yet to resolve globally.

By analyzing a successfully distributed vaccine population sample, such as Mongolia, to a sample that has suffered heavy loss due to unsuccessful allocation efforts, such as India, we can benefit by understanding the logistical, outbreak, and vaccination approaches that worked for Mongolia and might work for other countries in similar future situations. This study aims to answer the following major questions: (1) What insights can we obtain from Mongolia's COVID-19 vaccination success that can be implemented in India and other countries for vaccine allocation? (2) How effective were Mongolia & India's COVID outbreak containment strategies and vaccination policies? And (3) What made Mongolia more efficient in containing the pandemic as compared to India?

The study hypothesized that Mongolia's outbreak, containment, and vaccine allocation policies were highly efficient and insights can be derived from them that can benefit India and other countries in present and future.

Materials and Methods

The following are the three major components of this study:

- **Survey Development and Dissemination:** A cross-sectional and anonymous survey was developed and disseminated in India and Mongolia via social media from July 23, 2021 to August 6, 2021 on the topic *"Public Perception of COVID-19 Vaccination in India and Mongolia"*. The survey was originally developed in English and distributed as such in India but was translated into Mongolian for distribution in Mongolia. The major objectives of the survey were to understand and analyze the public perception of the residents on issues like challenges faced in vaccine distributions, safety/hesitancy concerns regarding COVID vaccine, effectiveness of vaccine and many others. The data collected was analyzed in JASP and SPSS through statistical techniques such as logistic regression, Pearson chi-squared tests, and Fisher's exact tests.
- **Policy Analysis:** To compare outbreak and vaccination policies qualitatively, the study used document analysis, a standard qualitative research method for evaluating communication and policy research, to explore differences and similarities between government COVID-19 guidelines in India and Mongolia. The following steps were included in the analysis: (1) gathering documents, (2) analyzing key areas, (3) finding insights. The research reviewed documents from publicly available government websites for each country, online newspapers/editorials, peer-reviewed articles, and heath institution guidelines.
- **Vaccination Modeling:** To visualize the vaccination allocation pipeline in India, a model, developed by Dr. Kim Warren, was used. A supply-and-demand model combined with data about the doses ordered, received, and spoiled to visualize this pipeline. The following steps were taken to analyze the vaccine distribution pipeline: (1) gathering data, (2) inputting data into the modeling software, and (3) simulating changes in the vaccination pipeline to predict future possibilities. Data was gathered from Indian and Mongolian government websites, reputable news sources, and Our World in Data.

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Tables and Figures

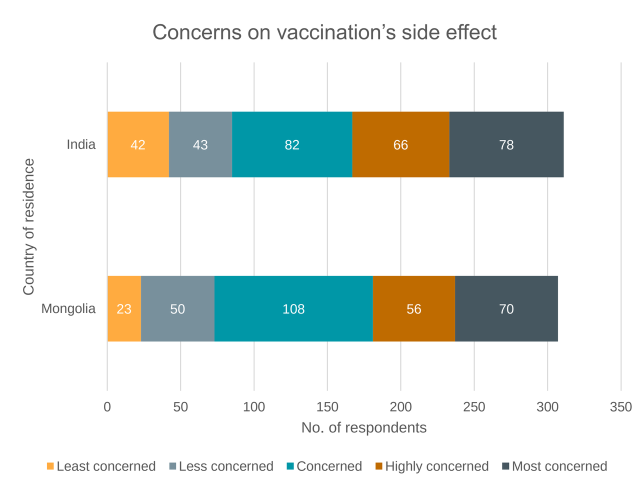

Figure 1. Concern of Indian and Mongolian survey respondents on side-effects of COVID-19 vaccine.

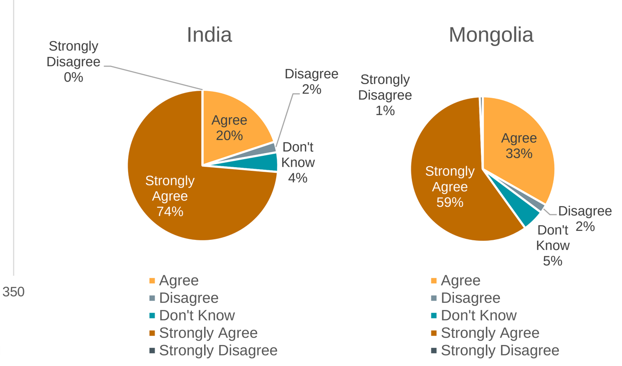

Figure 2. Perceptions of Indian and Mongolian survey respondents on the necessity of vaccination efforts to combat COVID-19 pandemic.

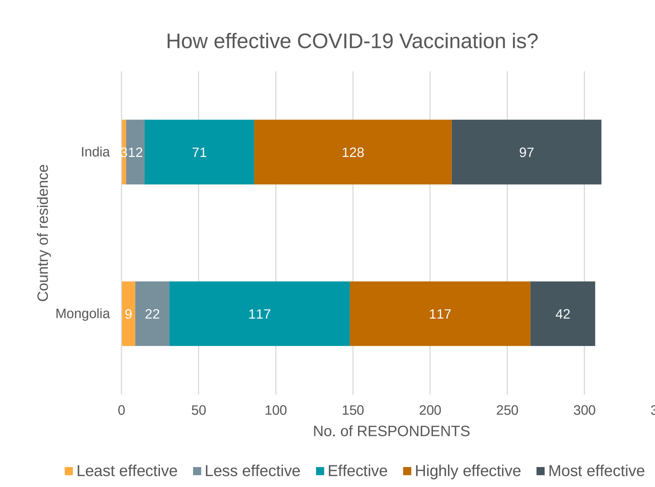

Figure 3. Perceptions of Indian and Mongolian survey respondents on effectiveness of COVID-19 vaccines.

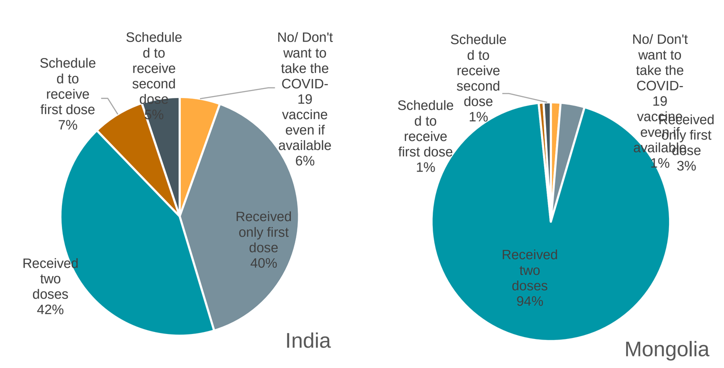

Figure 4. COVID-19 vaccination status in Indian and Mongolian survey respondents.

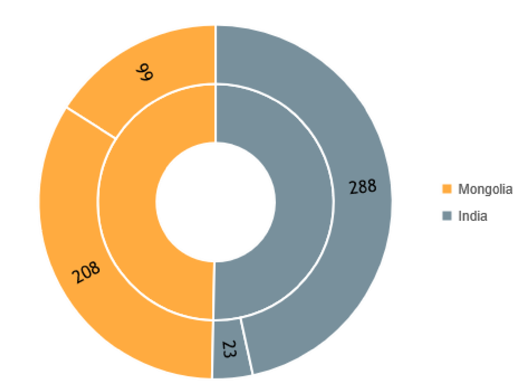

Figure 5. Perceptions of Indian and Mongolian survey respondents on distance from vaccination center as an obstacle to receiving vaccine.

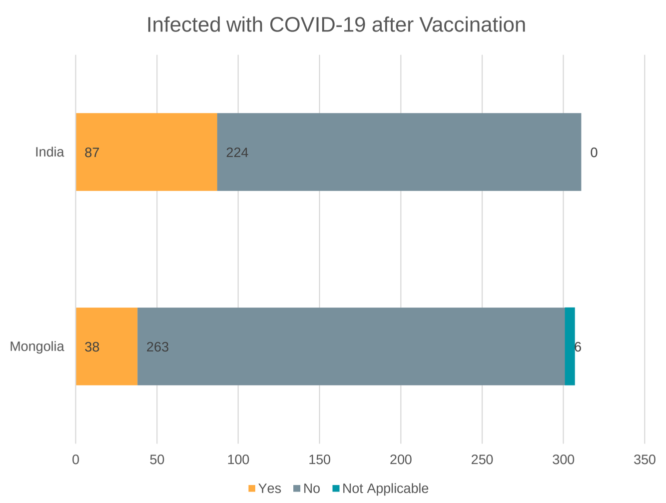

Figure 6. COVID-19 infections after first dose/second dose of vaccine.

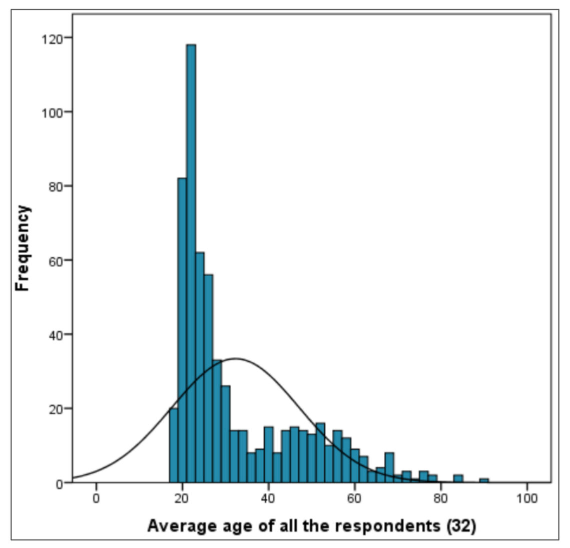

Figure 7. Age distribution of Indian and Mongolian survey respondents. Average age was determined to be 32.

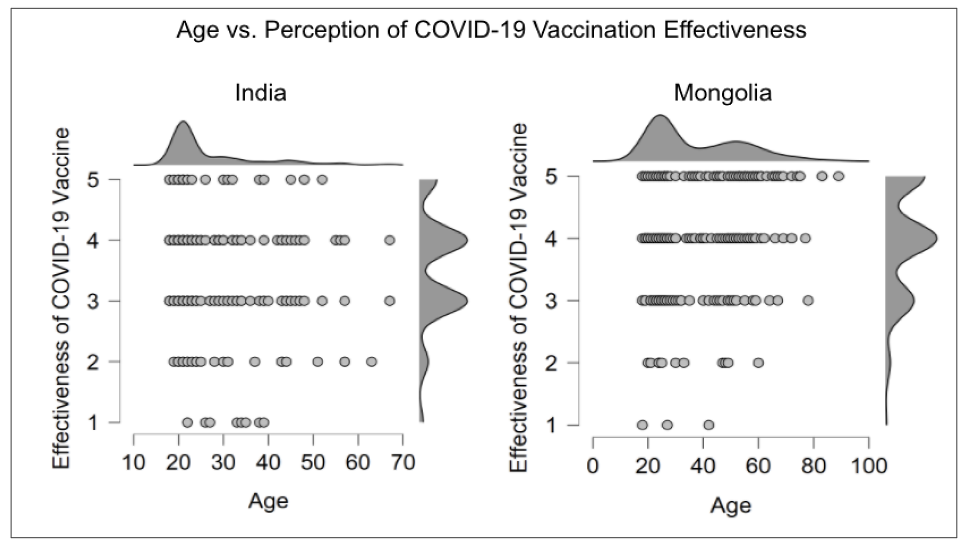

Figure 8. Relationship between age of Indian and Mongolian survey respondent and perception of COVID-19 vaccination effectiveness.

Independent Variables	B [95% C.I B]	S.E.	Wald	Odd ratio
Age	.005 [1, 1]	.010	.282	1.005
Country of Residence	-1.635 [0.1, 0.4]	.315	26.862***	.195
Type of settlement	-.507 [0.3, 1]	.248	4.173*	.603
Gender			.036	
Gender (1)	18.626 [0, 0.3]	20024.201	.000	122833437.196
Gender (2)	18.675 [0, 0.4]	20024.201	.000	128908045.447
Level of education			2.549	
Level of education (1)	-.322 [0.2, 2.4]	.616	.273	.724
Level of education (2)	21.655[0, 0.5]	40192.969	.000	2539171880.738
Level of education (3)	-.303 [0.2, 2.7]	.669	.205	.739
Level of education (4)	-.539 [0.3, 1]	.349	2.376	.584
Level of education (5)	-.002 [0.5, 1.7]	.285	.000	.998
Constant	-19.303	20024.201	.000	.000
Omnibus χ^2 (10) =73.43, p<0.001, R^2= 0.112 (Cox & Snell), 0.178 (Negelkerke)				
*p<0.05, ***p<0.001				
95% CI for EXP (b)				

Table 1. Logistic regression table comparing various independent variables (country of residence, rural/ubal set-up, gender and education level, age) and dependent variables (distance from vaccination center as an obstacle from getting COVID-19 vaccine)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.246[a]	1	.007		
Continuity Correction[b]	6.572	1	.010		
Likelihood Ratio	7.498	1	.006		
Fisher's Exact Test				.007	.005
N of Valid Cases	307				

Table 2. Chi-square test between distance from vaccination center as an obstacle for COVID-19 vaccination in rural/urban Mongolia (P<0.05).

Results

The key findings of this study are grouped as follows:

Survey Results: Of the survey respondents, 307 (49.68%) were from Mongolia and 311 (50.32%) were from India. There was more participation of the urban population as compared to the rural population in both countries (Mongolia: 65.15% (Urban) and 34.85% (Rural); India: 77.49% (Urban) and 22.51% (Rural)). Approximately an equal proportion of males (52.73%) and females (45.98%) participated in India whereas in Mongolia, female participation (79.48%) was much higher than male participation (20.52%). The average age of survey respondents across both countries was 32 years; the average in India was 37.5 years and the average in Mongolia was 27 years. Over 97% of the representative sample in both countries (97.72% in India and 98.39% in Mongolia) were aware about COVID-19 vaccination. **A Pearson Chi-Square test statistic (χ^2 (1) =0.367, P=0.545) suggested no significant association either between awareness regarding COVID-19 vaccination and country of residence or between COVID-19 vaccination awareness and the urban/rural area of Mongolia and India (P>0.05).** News channels (27.7%) emerged out as the most preferred source of COVID-19 vaccination information in India versus in Mongolia. A combination of news channels, doctors, friends/family/neighbours, social media, and government trusted sites (15.3%) was the most preferred. Over 50% of survey respondents from each country strongly agreed that vaccination was essential to combatting the COVID-19 pandemic (59.28% and 73.63% in Mongolia and India respectively). 75.57% of survey participants in Mongolia took the Sinopharm vaccine, while 74.28% of survey participants in India took the Covishield vaccine. **93.81% of participants in Mongolia had received two doses of the vaccine, while only 42.44% had in India**. **A higher percentage of respondents was infected with COVID-19 in India (27.97%) after getting vaccinated as compared to that of Mongolia (12.38%).** Surprisingly, more respondents thought the COVID-19 vaccine was very effective in India compared to Mongolia (31.19% versus 13.68%). **The major perceived challenges with vaccine allocation in India and Mongolia were a low supply of vaccines (India: 31.5%, Mongolia: 12.4%) and a lack of clear strategy (India: 12.2%, Mongolia: 18.9%). Both countries cited lack of information about vaccine side effects, safety, and effectiveness as the major concern regarding COVID-19 vaccination in their country (35% and 59.6% in India and Mongolia, respectively).** Individually, the distance from vaccination centers was not a major obstacle in both the countries. However, a **logistic regression analysis showed a significance influence of the country and region of residence on distance from a vaccination center as an obstacle for getting the COVID-19 vaccine (χ^2 (10)=73.43, P<0.001). A Pearson Chi-Square test statistic (χ^2 (1) =7.246, P=0.007) suggested a significant association between distance from the COVID-19 vaccination center and residency in rural/urban parts of Mongolia, but the same was not significant for India (χ^2 (2) =1.125, P=0.570).**

Policy Analysis Results: The following significant factors were found in Mongolia's early response for COVID-19 that perceivably helped prevent transmission: Early Travel Bans & Restrictions, Surveillance & Contact Tracking, Resource Availability, and other factors like single new source and simulation exercise. For vaccine allocation, it was found that vaccine diplomacy played a significant role in the success of vaccine allocation in Mongolia as the country imported vastly more vaccines when compared to their population. Whereas, India was not able to manufacture or receive the optimal quantity of vaccines for the entire population of 1.3 billion people. One key factor in Mongolia's vaccine allocation efforts which likely aided distribution is the mobile vaccine centres that were used to vaccinate people in hard to reach areas. As Mongolia is a very sparsely populated country, this step was essential in vaccinating the whole adult population.

Vaccination Model Results: A simulation in the model with a greater number of doses received by government and private vaccination centers yielded positive results for vaccine allocation as a larger percentage of the population received doses. Additionally, simulated vaccine allocation, taking into consideration approximately 700,000 undergraduate students who were required to be vaccinated as well as continued vaccination of priority groups 1 and 2 (neither of which have been fully vaccinated), gave the result that there would be a shortage of vaccines in the near future if India does not ramp up manufacturing.

Discussion

Mongolia's quick effort through early containment policies and strategic planning allowed for successful defenses against COVID-19 during a time of great distress for many developing countries, and made it possible for Mongolia to prevent the local transmission of the virus for around 10 months. During the policy analysis, we hypothesized that Mongolia's vaccine allocation strategy might be something very different in terms of strategy from India's. However, during our research we found that the major difference and contributor for vaccine success in Mongolia was the number of vaccines they received as compared to their population - which was an enormous amount. Despite Mongolia's status as a landlocked developing country, it utilized its strategic partnership with countries such as Russia, China, and India to gain sufficient resources. In February of 2021, India was able to donate approximately 15,000 vaccine doses to Mongolia; China and Russia together were able to donate millions of vaccines (although not reputable pharmaceutical company vaccinations) to Mongolia. A recent contribution by the USAID to Mongolia of $450,000 or around $1.3 billion tughrik were provided for COVID-19 relief. India's efforts with vaccine allocation with legislative policies and strategies during the second wave of COVID-19 were not as effective as other countries due to erratic nature of the virus and conflicting circumstances that were out of the public's control. Mass distribution of doses to other countries has left India with a sudden shortage of vaccines and with how quick new variants of COVID-19 spread, vaccine resources were insufficient to support such a large population in such a short period of time. However, the CDC has responded to the emergency taking place in India and has provided over 14 million dollars in specific for vaccine cost and treatment relief for disadvantaged regions of India.

Simulation via the vaccination allocation model showed that two-fold method is required to improve vaccine allocation methods via the production and distribution pipeline: increasing manufacturing in-house (via the Serum Institute of India and Bharat Biotech) and ensuring that a) vaccinations are mainly used in India (rather than distributing them to other countries; government allocation policies for public vs. private hospitals should also be revised) and b) the doses ordered are increased or decreased according to the vaccination rate such that that the spoilage rate of vaccines is minimized, especially in states where it is over 11% (Andhra Pradesh, Telangana, etc). Based on the current vaccination rate, India would need to vaccinated more than 200 million adults each month to have all adults vaccinated by the end of 2021. Various sources have noted that, while almost 400 million doses were placed on order by the Indian government in May, these have yet to be delivered (Menon, 2021). This information is backed up by the model simulation. Beyond increasing access to vaccinations and reducing hesitancy surrounding vaccination, factors such as the number of trained vaccinators, efficiency of trained vaccinators (directly influencing how many immunizations each can give in a day), and the days from order to receive vaccine doses should be considered in vaccination allocation policies. Increasing any one of these factors has a positive effect on the vaccination allocation in India. The pipeline from vaccine orders to vaccines received, combined with spoilage rate, has a significant effect on the number of jabs per day and should be made as efficient as possible. The results of the survey shows that there are not much significant differences in the public opinion towards COVID-19 Vaccination in India and Mongolia. However, variables like country of residence and urban/rural region do have significant influence on the vaccine accessibility. The results of the survey have the potential to devise necessary interventions.

Strengths of this study include the comprehensive three-pronged approach that was taken to effectively analyze the vaccine allocation efforts in Mongolia and India. Through three modes of analysis, the study collected novel primary data as well as cross-analyzed current secondary data. Current legislative policies in both Mongolia and India were analyzed to supplement the quantitative secondary data and qualitative primary data. Limitations to this study include that the survey sample did not equally represent all aspects of the population in both countries. In Mongolia, there were nearly twice as many female respondents for the survey compared to male respondents. Additionally, the majority of survey respondents in both countries were from urban areas rather than rural areas. There was a lack of public data surrounding vaccine administrations per day for different priority groups, which affected the simulated model. In the future, a survey should be disseminated for a longer period of time and it should be made certain that all demographics are represented proportionally (i.e. equal gender representation, equal urban/rural population representation, equal age representation, etc.). For future pandemic control, this study proposes incorporating effective, early restrictions and travel bans paralleled with large scale testing, an efficient healthcare system, and increased resource availability.

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