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# 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.

**Categories:** Public Health, COVID-19, Epidemiology, Immunology

**Key Words:** COVID-19, Vaccine Distribution, Vaccine Strategy, Public Health Response, Vaccine Modeling, India, Mongolia

 

## Background

The COVID-19 pandemic has posed unprecedented challenges on a global scale (Cucinotta & Vanelli, 2020; WHO, 2020), with COVID-19 cases beyond 207 million and deaths beyond 4.37 million reported as of August 17, 2021 (Mohamadian et al., 2021; WHO, 2021). The pandemic has further exacerbated the pre-existing vulnerabilities of developing countries, especially the healthcare infrastructure, poverty, and high population (Chowdhury & Jomo, 2020). Mongolia and India are two developing nations in Asia affected by COVID-19 and are in focus globally for their fight against COVID-19 in recent times. Mongolia is one of the least densely populated countries globally, as of 2019, with a GDP of 14 billion USD and a population of approximately 3.2 million. As of 2019, India is the second-most populated country globally, with a GDP of 2.871 trillion USD and a population of approximately 1.366 billion (World Bank, 2019).

As of July 2021, India reported the second-highest COVID-19 case count globally with a record 32.85 million cases in total, while Mongolia is 87th on the list with 0.18 million total cases (WHO, 2021). Between the two countries, India has witnessed more devastating consequences of COVID-19, with daily cases reaching up to 400,000 (Ritchie et al., 2021). On the other hand, Mongolia could contain COVID-19 local transmission for around ten months (January 2020 to November 2020); however, in March 2021, the country was hit hard by the second wave of the ongoing pandemic.

The Government of Mongolia started preventive steps in early January 2020, some weeks before WHO announced the COVID-19 pandemic, through the State Emergency Committee (SEC) and the adoption of the Disaster Protection Law. The shared approach was found on solidarity, early preventative actions, multi-sectoral collaboration, and a culture of continual development. Mongolia's strategy has been based on lessons learned from SARS outbreaks in 2003, H1N1 outbreaks in 2009, and seasonal influenza epidemics, with the Asia Pacific Strategy for Emerging Diseases and Public Health Emergencies (APSED) being used to prepare for the next pandemic. It relied on thorough surveillance and contact tracing, a well-prepared health system, and a high degree of community knowledge of health protection and promotion activities (WHO, 2020)

Difficulties regarding vaccine distribution have been a significant obstacle following the development of the COVID-19 vaccine. Various challenges persist, from securing vaccines to crossing several impediments to administering the vaccine (Wouters et al., 2021). Countries either lacked a sufficient number of vaccines for their citizens or the means of distributing those vaccines effectively. Prioritizing vaccine distribution efforts among those most severely impacted by the pandemic is another complication that ensued (Fielding et al., 2021; Gupta and Morain, 2020; Wu et al., 2020). The lack of robust infrastructure and logistical solutions is an issue many nations have yet to resolve (Choi et al., 2021; Williams et al., 2021).

Both Mongolia and India have been successful in securing vaccines by the early quarter of 2021. India, possessing the resources to develop the vaccine and having institutions at the forefront of vaccine development, such as the Serum Institute of India, Zydus Cadila, and Indian Immunologicals, have played a significant role in global vaccination efforts (Pagliusi et al., 2020). India has been responsible for developing two major in-house vaccines on par with Pfizer, Moderna, and J&J: the Serum Institute of India’s ‘Covishield’ vaccine and Bharat Biotech’s ‘Covaxin’ (Bagcchi, 2021). Although there are no vaccines currently being developed in Mongolia, the Mongolian government has successfully procured vaccines through global facilities and approved six vaccines for use, including Sinopharm, AstraZeneca, Sputnik, and Pfizer (McGill University, 2021). With the help of the COVAX facility, Mongolia 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).

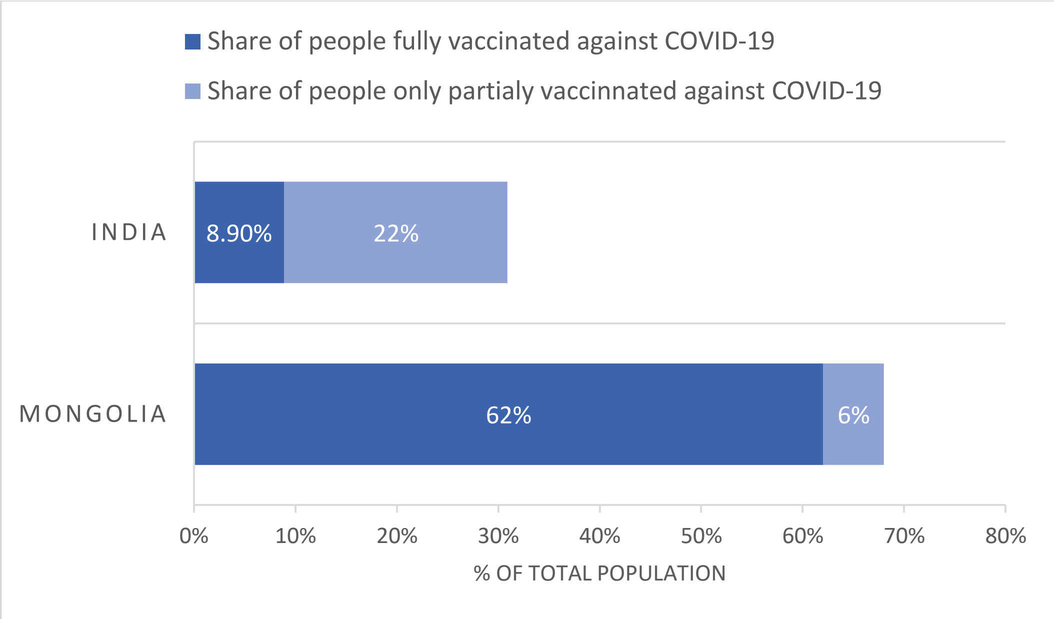


*Figure 1[1]: COVID-19 Vaccination Summary of Mongolia and India as of August 17, 2021*

Several vaccination models have been used to determine the optimal vaccination strategy for COVID-19 in various countries. One study, conducted in the United Kingdom, highlighted vaccination strategy as the primary method for reducing virus transmission and returning to normal behavior, stating that despite the enforced social distancing and lockdown procedures there, a large pool of COVID-19 susceptible individuals remains vulnerable (Moore et al., 2021). From this analysis, they determined that five main factors can influence the success of any vaccination distribution strategy: (1) characteristics of the vaccine, such as vaccines that solely reduce susceptibility compared to vaccines that reduce disease, (2) the efficacy of the vaccine, (3) the reproduction number after vaccination distribution has been completed, (4) the proportion of the population fully vaccinated, and (5) vaccination of priority groups, such as the elderly, first (Moore et al., 2021). Another study conducted in Italy compared different scenarios to assess the effect of mass vaccination campaigns with different paces (Giordano et al., 2021). In addition, Foy et al. (2021) used the SEIR (Susceptible, Exposed, Infectious, Recovered) model in their study to examine vaccine distribution strategies in India. The age-structured SEIR mathematical model showed a significant relationship between prioritizing vaccination in older age groups and the most effective overall reduction in COVID-19 morbidity and mortality rates. By considering various variables before concluding, such as vaccination production, vaccine rollout speed, and other implications of immunology, the SEIR model proved to show an incredibly effective COVID-19 vaccine distribution plan throughout multiple regions in India (Foy et al., 2021).

However, Vaccine hesitancy and stigma on COVID-19 have still dented the global vaccination efforts. According to the experts, the primary reason behind this drop is the vaccine hesitancy among the people. Facebook's COVID-19 Symptom Survey (CSS) in India has found that the vaccine hesitancy rate is around 28.7% (Swamy, 2021). Comparing this value to the daunting population size of India further implicates the dangers of public perception and how a lack of information can significantly impact the general health of a nation. Thus comes the need for this study.

[1] Source: Hannah Ritchie, Edouard Mathieu, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Esteban Ortiz-Ospina, Joe Hasell, Bobbie Macdonald, Diana Beltekian and Max Roser (2020) - "Coronavirus Pandemic (COVID-19)". *Published online at OurWorldInData.org.* Retrieved from:https://ourworldindata.org/coronavirus

 

The study has three major objectives: 1) to obtain insights from Mongolia's COVID-19 vaccination pipeline that can be implemented in India and other countries for vaccine distribution, 2) to analyze and compare the effectiveness of Mongolia & India's COVID outbreak containment strategies and vaccination policies, and 3) to assess and compare the public perception of the residents of India and Mongolia on various COVID-19 vaccine issues like accessibility, vaccine allocation policies, vaccine hesitancy/safety, challenges faced, etc.

This study hypothesized that (1) Mongolia's outbreak, containment, and vaccination allocation policies were highly efficient, (2) a significant difference between public perception of COVID-19 vaccination in India and Mongolia would not be present, (3) outbreak containment policies would not have much effect on the cases and vaccination rates, (4) Mongolia's vaccination distribution was very different from that in India, seeing how efficiently they distributed the vaccines in a short period, and (5) insights can be derived from differing vaccine distribution strategies that could benefit other countries in the present and future.

## Methodology

This study utilizes a mixed-method approach. The methodology consists of 1) policy analysis, 2) survey, and 3) vaccination modeling. A detailed description of these methods are as follows:

**Policy Analysis:** To compare outbreak and vaccination policies qualitatively, the present study used document analysis (Dalglish et al., 2021; Rasmussen et al., 2012), a standard qualitative research method for evaluating communication and policy research and exploring the differences and similarities between COVID-19 measures and vaccine allocation policies in India and Mongolia. The following steps were included in the analysis: (1) gathering data, documents through publicly available government websites for each country, journals, online newspapers/editorials, peer-reviewed articles, and health institution guidelines, (2) analyzing key areas, including COVID-19 response policies (travel bans, travel restrictions, surveillance, etc.) and vaccine distribution factors (vaccine diplomacy, availability of vaccines, etc.), and (3) finding insights.

**Survey:** A cross-sectional, online, anonymous survey on the topic "Public Perception of COVID-19 Vaccination in India and Mongolia" was developed and disseminated through social media platforms like WhatsApp, Facebook, Instagram, and Discord in India and Mongolia (Annexure I). To create the structured questionnaire, an in-depth literature survey was conducted to iteratively synthesize a comprehensive list of questions based on broad content areas reported in previously published survey research on pandemics (El-Elimat et al., 2021; Kumari et al., 2021). The questionnaire required an estimated time of 3–4 minutes to complete and was structured into two sections: Demographics and COVID-19 Vaccination. Respondents were ensured about the confidentiality and privacy of their responses. The questionnaire was initially developed in English and distributed as such in India but was translated into Mongolian for distribution in Mongolia. Snowball sampling technique (Heckathorn, 2011) was used to collect the samples. The data collected from the questionnaire were analyzed in software such as JASP, SPSS, and Microsoft Excel. Inferential statistics (such as logistic regressions, Pearson chi-square tests, Fisher's exact tests, and Spearman's Rank-Order Correlations) were performed to assess any significant relationships between various variables and identify the influencing variables. Notably, as Mongolia is farther into the vaccine distribution effort, an additional question regarding the major incentive (i.e., cash benefits, access to indoor services and domestic travels, etc.) for getting vaccinated was added in the Mongolian survey.

**Vaccination Modeling:** A vaccination distribution model developed by Dr. Kim Warren at Strategy Dynamics was used to visualize the vaccination distribution pipeline in India (Strategy Dynamics Ltd, 2021). The model was built on the Silico platform, a web-based modeling software. It utilized a supply-and-demand model combined with data about the doses ordered, received, and spoiled over a period of time to visualize the vaccine distribution pipeline in India. The following steps were taken to analyze the vaccine distribution pipeline: (1) gathering data from the Indian government website, reputable news sources such as Times of India, BBC, and Oxford University databases, (2) inputting data into the modeling software, and (3) simulating changes in vaccine distribution strategy to predict future outcomes. Cumulative vaccination data from Oxford University's 'Our World in Data' project was subtracted for consecutive days to determine the number of vaccines administered each day from January 16, 2021 (when distribution began in India) to July 31, 2021. After July 31, 2021, vaccine distribution was simulated using predicted values provided by the Indian government (Arora and Banerjee, 2021; Prasad and Sharan, 2021).

Critical vaccine coverage ($v_c$) is used to estimate population vulnerability to COVID-19 in each country. The critical vaccine coverage refers to the fraction of a country's population that needs to be vaccinated in order for the country to reach an effective reproduction ratio of 1 (Duijzer et al., 2016). The formula given in Equation 1 was used to estimate critical vaccine coverage, where E is the effectiveness of the COVID-19 vaccination (with E = 1 referring to a vaccine that is 100% effective) and $R_0$is the basic reproduction number for COVID-19 in each country, or the average number of new infections caused by an infected individual in a fully susceptible population (Britton et al., 2020).

$$v_c = E^{-1}(1 - \frac{1}{R_0}) \text{ ................................... } \textit{Equation 1}$$

Here, the Covishield and Sinopharm vaccines were used in the calculation for India and Mongolia, respectively, as a majority of the population in each country took these respective vaccines (Dashdorj et al., 2021; Padma, 2021). Values for "E" in Mongolia and India were 0.54 and 0.9, respectively (Liu and Rochabrun, 2021; Lopez Bernal et al., 2021). For both countries, $R_0$ was taken from previous research studies that used the "R0" package in R as well as an exponential growth method to estimate the dynamic effective reproduction number in each country (Marimuthu et al., 2020). From these studies, $R_0$ in Mongolia was found to be 1.45, with a 95% confidence interval of 1.31 and 2.16, and $R_0$ in India was found to be 1.379, with a 95% confidence interval of 1.375 and 1.384 (Ayoub et al., 2020; Marimuthu et al., 2020).

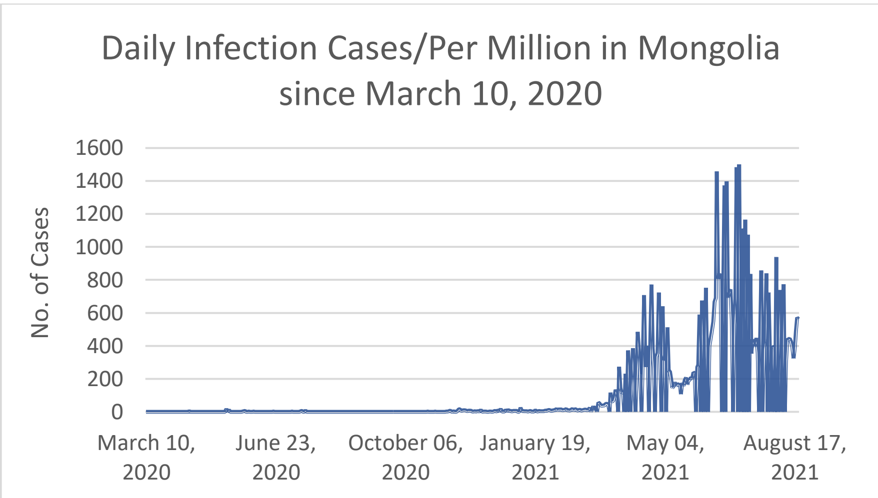


*Figure 2[2]:Daily new COVID-19 cases per million people in Mongolia, March 10, 2020, to August 18, 2021*

[2] Source: Hannah Ritchie, Edouard Mathieu, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Esteban Ortiz-Ospina, Joe Hasell, Bobbie Macdonald, Diana Beltekian and Max Roser (2020) - "Coronavirus Pandemic

 

As vaccines are not 100% efficient in preventing infections, there is still a vaccinated vulnerable population in both India and Mongolia. In recent months, Mongolia has had an upsurge of cases (figure 2) even after fully vaccinating 63.1% of its population as of August 1, 2021. Therefore, we have estimated an approximate range of vulnerable populations in Mongolia and India to visualize the number of people that are still highly susceptible to COVID-19 infection even after vaccination.

*Equation 2* was used to calculate the number of vulnerable people after vaccination in each country, where $\alpha$ refers to the average percentage of vaccine efficacy and $\beta$ refers to the number of total doses administered (in India's case, first doses, and in Mongolia's case, total second doses).

$$V = (100 - \alpha) \times \beta \quad \text{.................................... } \textit{Equation 2}$$

## Results

**Policy Analysis:** The national COVID-19 response of both countries has been evaluated to check on the containment measures in both India and Mongolia. The containment policies are among the major steps in minimizing the pandemic risks. Through the policy analysis, we aimed to find conclusive results on Mongolia's policy response in containing the local transmission of the virus for about 10 months.

***Mongolia:***
Travel bans and restrictions were a key factor in Mongolia's early response. So far, early border inspections have shown to be one of the most successful preventive strategies, resulting in surprisingly low infection rates in Mongolia. On January 9, the World Health Organization (WHO) revealed that the cause of the viral pneumonia was a new coronavirus. While several governments waited, Mongolia issued an advice requiring all Mongolians to wear masks the next day. As the worldwide situation worsened in January and more nations reported instances, Mongolia swiftly tightened its controls, banning travel from China & various other countries and isolating people travelling from COVID-19-infected countries. Mongolia cancelled celebrations of the Lunar New Year—Tsagaan Sar, the country's most important yearly holiday—in late February before any cases were verified (Erkhembayar et al., 2020).

Surveillance & contact tracing in the early stages were also key factors present in Mongolia's early policy response. A systematic contact tracing monitoring system was established before the end of February to allow necessary observation and isolation of contacts in order to prevent the disease spreading. In early March, after displaying COVID-19 symptoms, a French person violated his quarantine, then tested positively for the virus. It took just six days to trace, test and isolate all 181 contacts of the patient from the announcement of his positive test on March 10, 2021 (Erkhembayar et al., 2020).

Other factors in the early policy response include, firstly, Mongolia undertaking a major national simulation exercise, which was intended to do everything possible to keep COVID-19 out of business. The simulation exercise identified important system flaws and stressed the necessity of continuous improvement (Sharing COVID-19 Experiences: The Mongolian Response, 2020). Secondly, Mongolia's authorities kept the people informed through text messages and regular updates to the nation across all broadcast media; clear and reliable information came from a single source, removing unnecessary misunderstanding and potential misinformation. These factors also included quarantining and testing all travellers, random community testing, walk-up testing clinics and the creation of isolation and quarantine camps—all set up in the month of February 2020, before the country's first case. The camps were created as it was not possible for many to quarantine at home. Those suspected

(COVID-19)". *Published online at OurWorldInData.org.* Retrieved from: 'https://ourworldindata.org/coronavirus' [Online Resource] of having COVID-19 and those who had been close contacts with confirmed COVID-19 cases were required to stay in the camps for monitoring. All COVID-related health care was provided free of charge, apart from charges for meals.

**Vaccine Allocation Strategy in Mongolia:** The Mongolian government aimed to vaccinate 60% of the total population or 1,978,120 people. The order of priority and numbers of targets are summarized in Table 1. The first three target groups will comprise 20% of the population. By initially prioritizing these groups, the vaccination program achieved its impact in reducing the consequences of the pandemic even in conditions of vaccine supply constraints. When subsequent consignments of vaccine become available, up to 60% of the population or all adult population will be vaccinated. As of August 16, 2021, Mongolia has fully vaccinated 62.7% of its population, reaching the above-mentioned target rates.

*Table 1[3]: COVID-19 vaccination priority groups in Mongolia*

| **Target Group** | **Number of Target Population** | **Target Population's Share of Total Population (%)** |
|---|---|---|
| 1. Health care workers in public and private health facilities | 56,047 | 1.7 |
| 2. Multisector personnel working in national COVID-19 response activities, including frontline workers from the National Emergency Management Agency, General Agency for Specialized Inspection, border control, and police department | 52,570 | 1.6 |
| 3. Older adults aged 50 and above | 583,545 | 17.7 |
| 4. People with disabilities | 230,781 | 7.0 |
| 5. People who suffer from chronic comorbidities | 276,937 | 8.4 |
| 6. Additional workers and volunteers deployed for vaccination | 65,937 | 2.0 |
| 7. Vulnerable groups requiring social welfare assistance | 313,202 | 9.5 |
| 8. Workers from strategically important sectors whose services will continue without disruptions | 329,687 | 10.0 |
| 9. Staff from educational facilities, including kindergartens, elementary, secondary, and high schools, and higher educational institutions | 69,234 | 2.1 |
| **Total** | **1,978,920** | **60.0** |

At the time, many developing countries were struggling to find countries that were able to distribute vaccines to other countries, creating a worldwide shortage. 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 as well throughout the first six months of 2021, according to many Mongolian news outlets. Mongolia being a country covered vastly with grasslands, prepared a mobile vaccination team to reach the hard-to-reach areas in

[3] *Source:* Government of Mongolia, State Emergency Commission, 2021. *About Approving National Deployment and Vaccination Plan against COVID-19.* Order of the Chair of the State Emergency Commission, No. 5. Ulaanbaatar.

 

the country as they aimed to vaccinate 100% of the adult population. This strategy proved to be beneficial and more countries should implement the same. Mongolia's effort with vaccine allocation through legislative policies and strategic planning allowed for successful defense against COVID-19. Through this, Mongolia was able to become a country recognized for its success in containment and efficient treatment of COVID-19. Despite all these measures, Mongolia has had an upsurge of new cases in the past few weeks, which is mainly due to the efficacy of the vaccines. Refer to section (Vaccination Modelling for more info on this).

***India:***

India has had very strict restrictions with travel and commerce in its country through enforced lockdown measures and regulation of many activities. On March 24, 2020, India implemented a national lockdown policy mandated by the government (called Lockdown 1.0) which was revised into three subsequent stages (Lockdown 2.0-4.0) to attempt to flatten the curve of COVID cases (Thayer et al., 2021). While these lockdown measures were effective, cases began to spike again when measures were loosened on July 1, 2020 (known as Unlockdown 1.0) and following such, restrictions loosened until November (Unlockdown 6.0). However, the rise of the second wave of COVID in February 2021 led to more stringent measures to avert the collapse of the healthcare system of India. On April 4, 2021, another lockdown policy was implemented until April 30 of the same year in order to contain the spread of the virus. The lockdown was extended as government officials saw no visible decrease in the trend of cases in the near future. 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 the erratic nature of the virus and conflicting circumstances that were out of the public's control. However, the current status of public health in India is beginning to show improving patterns with restrictions starting to loosen and the economy opening up again.

**Vaccine Allocation Strategy in India:** On 19 April 2021, the Press Information Bureau (PIB) made public the details of India's COVID-19 vaccination strategy (Press Information Bureau, April 2021), which focused on the scale and speed for the third phase. In respect of the vaccine doses provided free of cost by the Government of India to the States, vaccination is prioritized as the following: Health Care Workers, Front Line Workers, Citizens more than 45 years of age, Citizens whose second dose has become due, Citizens 18 years & above. The first phase of India's COVID-19 mass inoculation program was launched on 16 January, covering an estimated 30 million healthcare and front-line workers (Indian Government Guidelines, 2021). On the first of March, the country initiated the second phase, aiming to cover people above-45 with co-morbidities and the cohort above 60. This was expanded on 1 April to cover everyone above 45 years, bringing the total to over 300 million people. While this number accounted for only 22 percent of the population, they were also the high-risk and most vulnerable, accounting for 80 percent of recorded COVID-19 mortality in the country (Press Information Bureau, May 2021). The expected timeframe for completing the vaccination drive was six months from the launch. From May 1, the government expanded its vaccination program to all those above the age of 18 and till now has administered around 571 million doses.

Several factors have been identified that have benefitted the country's action to create widespread treatments and to improve public health numbers. India has been one of the main contributors of vaccine diplomacy during the pandemic, with sources estimating a range of 45 to 58 million vaccine doses being allocated to over 20 different developing and devastated countries. Through this, India has become one of the world's top vaccine developers, with companies such as Serum Institute of India and Zydus Cadila leading the front. However, the mass distribution of doses has left India with a sudden shortage, and with how quickly new variants of COVID-19 spread, vaccine resources were insufficient to support such a large population in such a short period of time. However, India is now seeing a reflection of their kindness. Mongolia, for example, received thousands of vaccinations from

India during a wave of COVID-19. After India was hit by the second wave, Mongolia was able to donate $1 million for vaccine and treatment relief as well as other resources that they had available to themselves. Currently, as of July 2021, India has approved Johnson & Johnson and Moderna vaccine doses to be used and will start to be distributed beginning late August. Pfizer is still undergoing testing but all three American pharmaceutical companies are willing to work with the Indian government to provide resources in mass orders.

Since March 2020, 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. They have also provided thousands of laboratory equipment and oxygen tanks for hospitals that are desperate for supplies. Direct Relief is another organization that has come to aid India during their state of emergency, with $437 million and 24 million vaccinations donated by April of 2021. Direct Relief has helped India distribute these resources as well to hospitals in all regions, many of which were lifesaving treatments and vaccine doses at a cost-efficient rate. Other countries have begun to provide relief to India, with the US donating over $25 million in July and more in August.

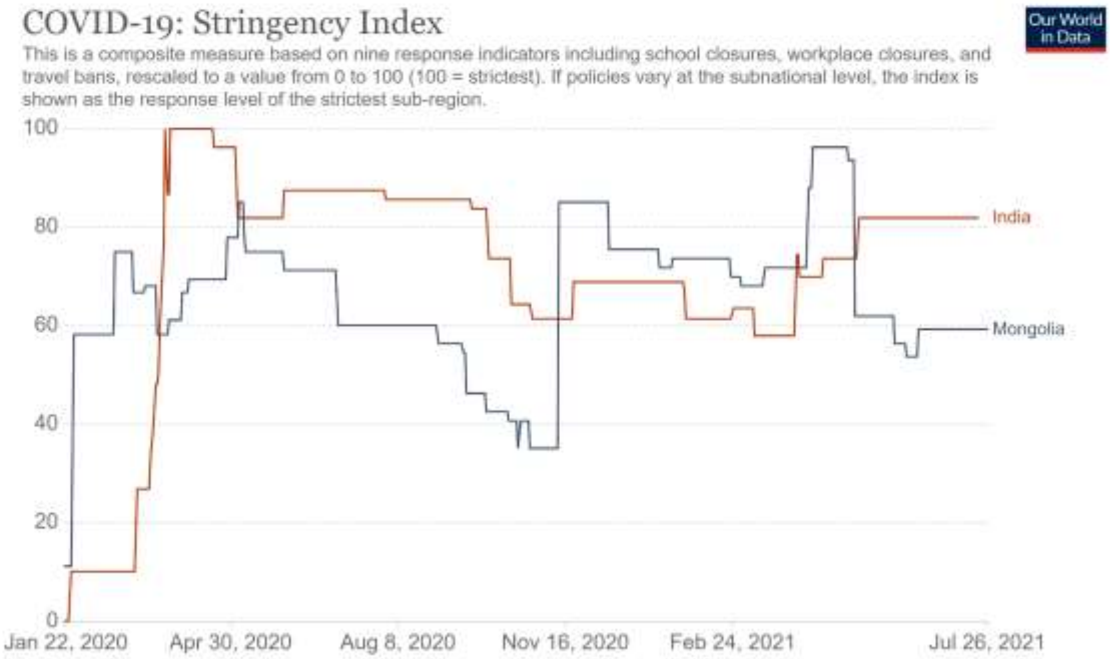


*Figure 3[4]:Comparison of restriction measures in both countries*

The ‘Our World in Data’ database was used to formulate the graph shown in Figure 3, which compares the stringency index of India and Mongolia simultaneously. The stringency index measures the composite strictness of nine measures which include school closures, workplace closures, and travel bans (Cross et al., 2020). The scale of the graph is from 0 to 100, where strictness ranges from 0 to 100 (low to high) (Cross et al., 2020).

Mongolia was quick to implement restrictions as compared to India which is evident from near ‘60’ stringency index on January 22nd, 2020. During the first three months of 2020, India didn’t have

[4] **Source:** Hannah Ritchie, Edouard Mathieu, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Esteban Ortiz-Ospina, Joe Hasell, Bobbie Macdonald, Diana Beltekian and Max Roser (2020) - "Coronavirus Pandemic (COVID-19)". *Published online at OurWorldInData.org.* Retrieved from: 'https://ourworldindata.org/coronavirus' [Online Resource]

 

much restrictions, especially on travel bans. It implements strict restrictions starting from around March 19th, 2020.

The following significant factors were found in Mongolia's early response for COVID-19 that perceivably helped prevent transmission:

Firstly: Early Travel Bans & Restrictions, Surveillance & Contact Tracing, Resource Availability, and other factors like single new source and simulation exercise. The vaccine diplomacy played a significant role in the success of vaccine distribution in Mongolia as the country imported vastly more vaccines when compared to their population. On the other hand, India was not able to manufacture or receive the optimal quantity of vaccines for the entire population of 1.366 billion people (World Bank, 2019). Second: one key factor in Mongolia's vaccine distribution 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. Third: resource allocation and availability policies greatly varied in outcome as Mongolia was able to receive treatments and supplies from allies such as China and Russia while India had extreme shortages in hospitals and treatment centers. Fourth: as for the vaccine allocation in Mongolia & India, the major difference was vaccine diplomacy in Mongolia that resulted in a huge supply of vaccines when compared to India, mainly due to the enormous population size difference. Fifth: other policies addressing restrictions & travel bans, surveillance, and contact tracing had similar designs but differing outcomes, many of which were successful in Mongolia but less so in India.

## Survey

**Profile Characteristics:** A total of 618 respondents participated in the public perception survey on COVID-19 Vaccination with 307 (50%) respondents from Mongolia and 311 respondents (50%) from India (Figure 4). There was more participation of the urban population as compared to the rural population in both countries (Mongolia: 65% (Urban) and 35% (Rural); India: 77% (Urban) and 23% (Rural)). Approximately an equal proportion of males (53%) and females (46%) participated in India whereas in Mongolia, female participation (79%) was much higher than male participation (21%) (Figure 5). The average age of respondents across both countries was 32 years; the average ages of the respondents in India and Mongolia were 37.5 years and 27 years respectively representing major participation from the younger segment of society (Figure 6). In terms of the level of education completed/ pursuing, the participation of postgraduates (58%) was the highest in India followed by that of undergraduates (23%). Whereas, in Mongolia, participation of the undergraduates (64%) was the highest followed by the participants who are pursuing/ have completed school education (22%) (Figure 7).

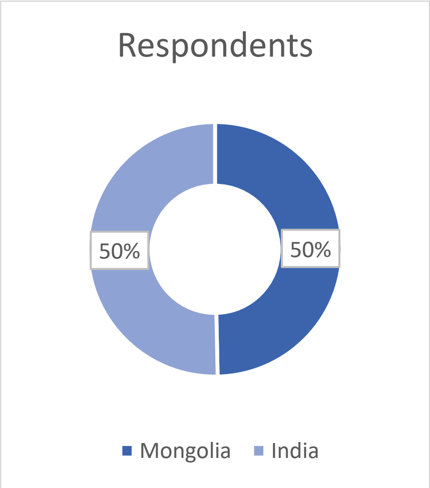


*Figure 4: Total no. of Respondents*

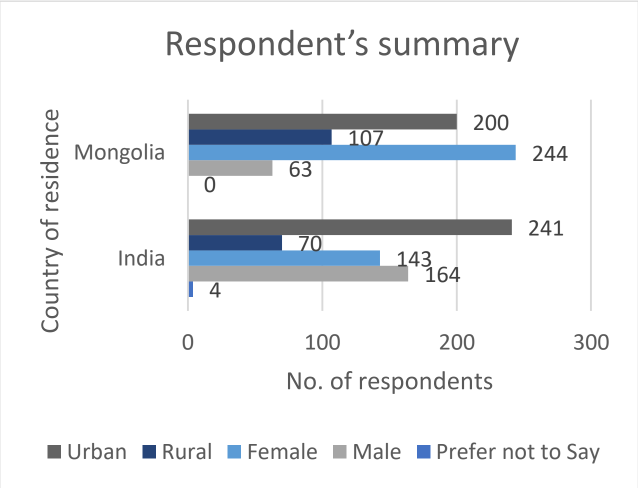


*Figure 5: Respondent's summary with demography*

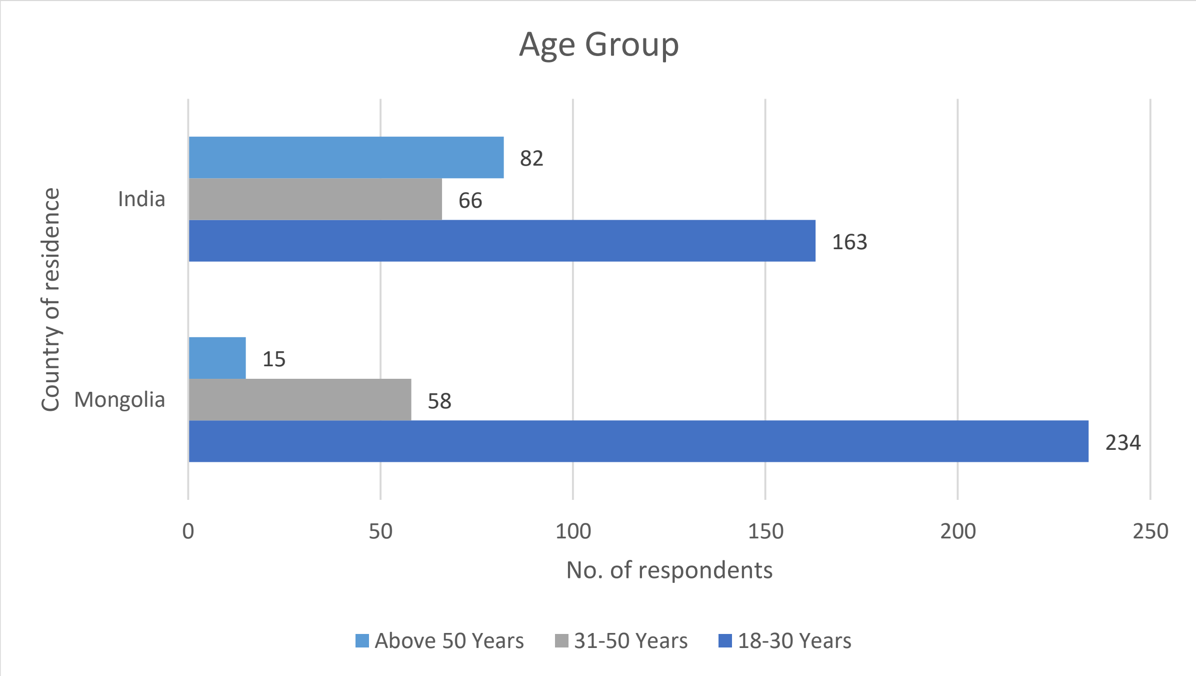


*Figure 6: Respondents by Age-Group*

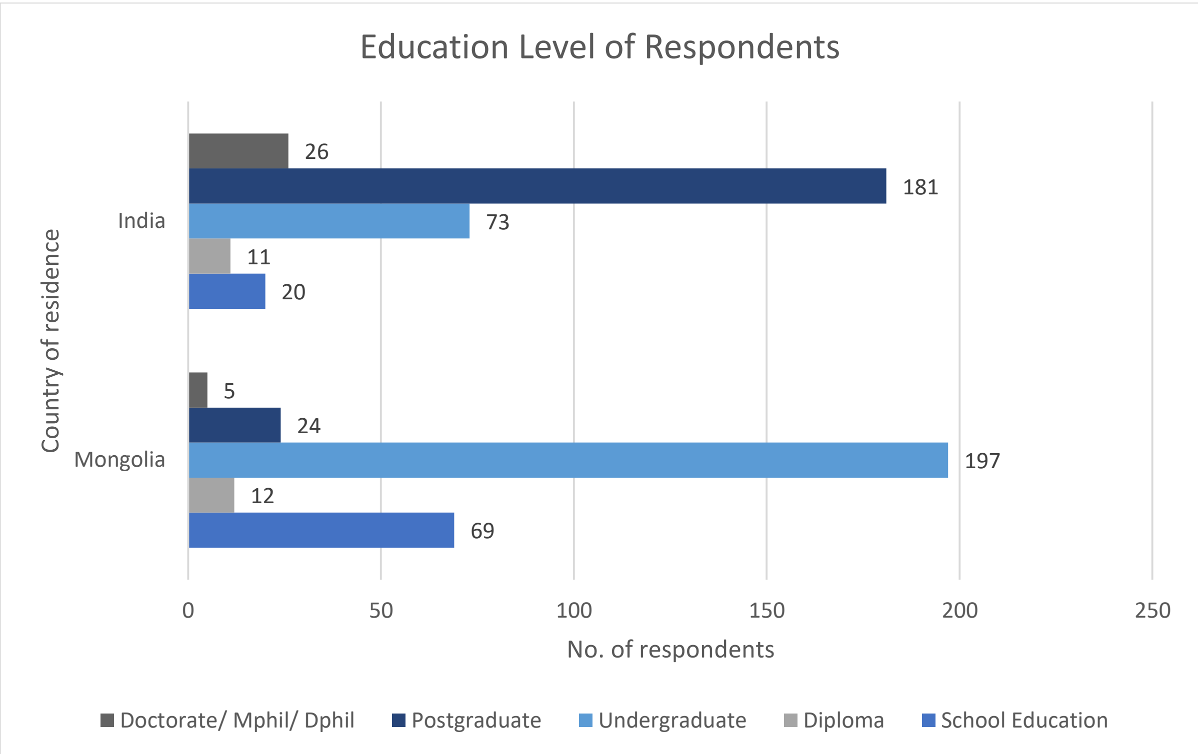


*Figure 7: Qualification details of the respondents*

**COVID-19 Vaccination:** Over 97% of the representative samples in both countries (98% each in India and Mongolia) were aware about COVID-19 vaccination (Figure 8). A Pearson Chi-Square test statistic ($\chi 2$ (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 (28%) emerged as the most preferred source of COVID-19 vaccination information in India. A combination of news channels, doctors, friends/family/neighbors, social media, and government trusted sites (15%) was the most preferred in Mongolia (Table 2). Over 50% of survey respondents from each country strongly agreed that vaccination was essential to combatting the COVID-19 pandemic (59% and 74% in Mongolia and India respectively). Around 4% of the respondents in India (4%) and Mongolia (5%) opted 'Don't know' (Figure 9). 76% of survey participants in Mongolia took the Sinopharm vaccine, while 74% of survey participants in India took the Covishield vaccine (Figure 12). Over 90% of the respondents in India (96%) and Mongolia (90%) have taken the vaccine/ willing to take the vaccine when available. The remaining population are either not sure or don't want to take it (Figure 10).

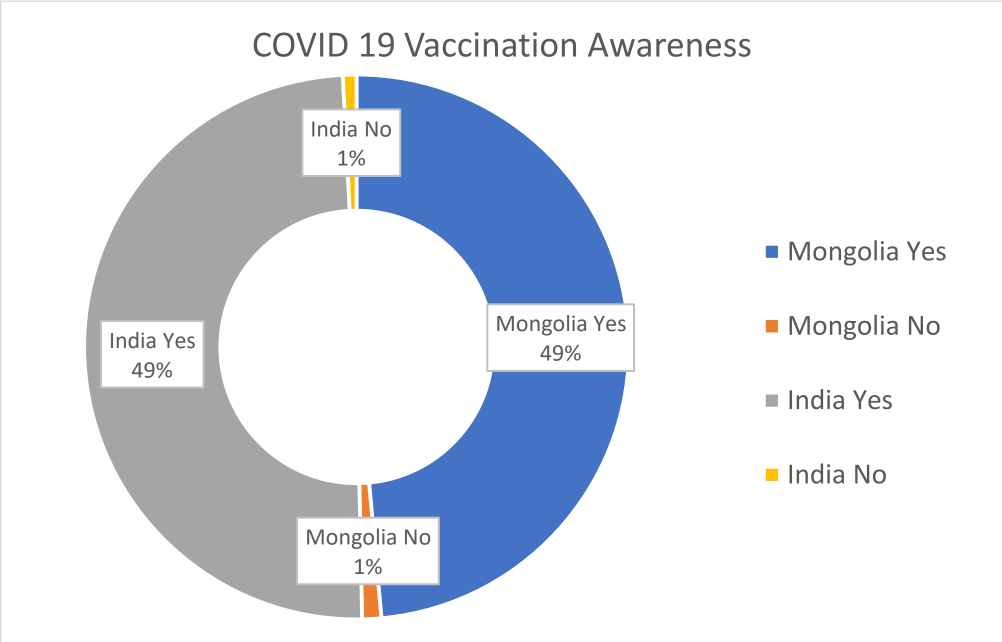


*Figure 8: Vaccine awareness among the respondents*

*Table 2: Source of information for vaccination in both countries*

| **India** | **Respondents (%)** | **Mongolia** | **Respondents (%)** |
|---|---|---|---|
| News channels, | 28% | News channels, Doctors Friends/family/neighbors, social media government's trusted site | 15% |
| News channels, Doctors, social media, Government's trusted site | 19% | News Channels (TV, radio, newspaper etc.) | 11% |
| Government's trusted site | 16% | News channels, social media | 9% |
| Social media | 6% | Social media | 8% |

 

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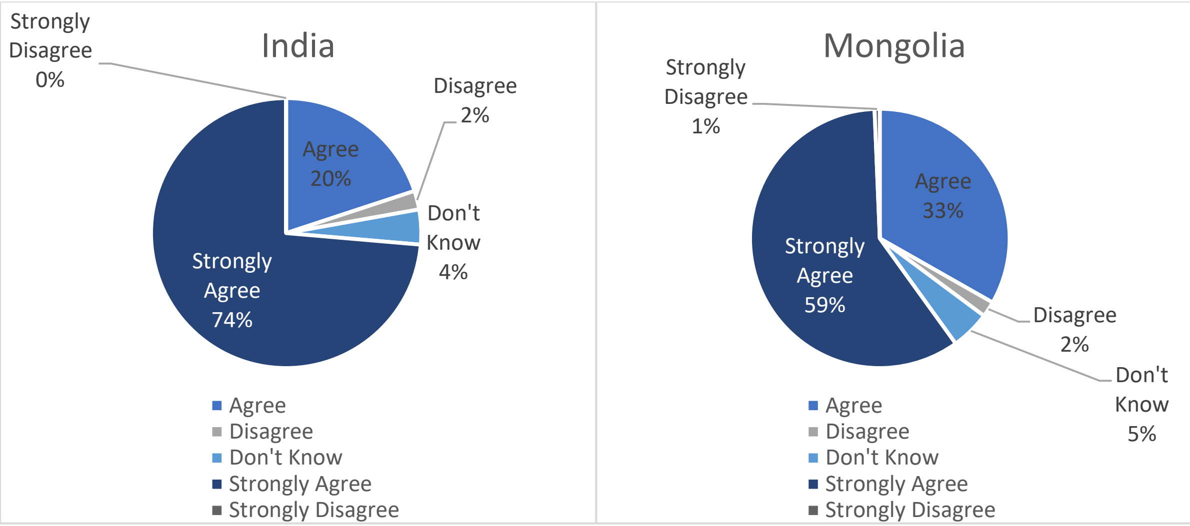


*Figure 9: Respondent's view on necessity of vaccination for combating COVID-19*

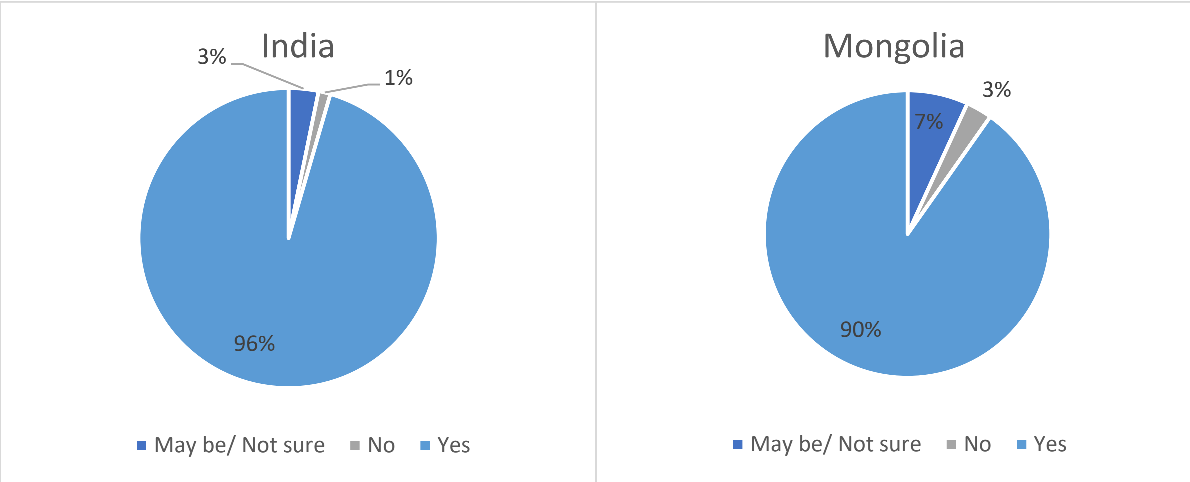


*Figure 10: Respondent's response on willingness to take vaccine*

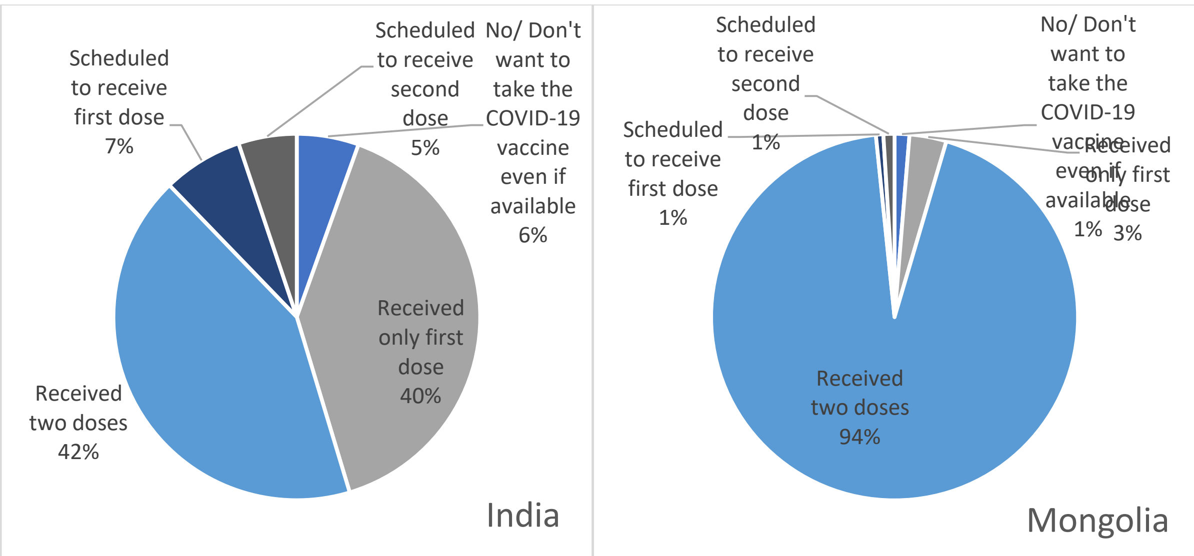


*Figure 11: Vaccination status of the respondents in both countries*

94% of participants in Mongolia had received two doses of the vaccine, while only 42% had in India (Figure 11). A higher percentage of respondents were infected with COVID-19 in India (28%) after getting vaccinated as compared to that of Mongolia (12%) (Figure 13). Surprisingly, more respondents thought the COVID-19 vaccine was very effective in India compared to Mongolia (31% versus 14% respectively) (Figure 17). The major perceived challenges with vaccine distribution in India and Mongolia were a low supply of vaccines (India: 32%, Mongolia: 12%) and a lack of clear strategy (India: 12%, Mongolia: 19%) (Figure 14). In Mongolia, the major driving force for getting vaccinated was a combination of protecting oneself and family (52%).

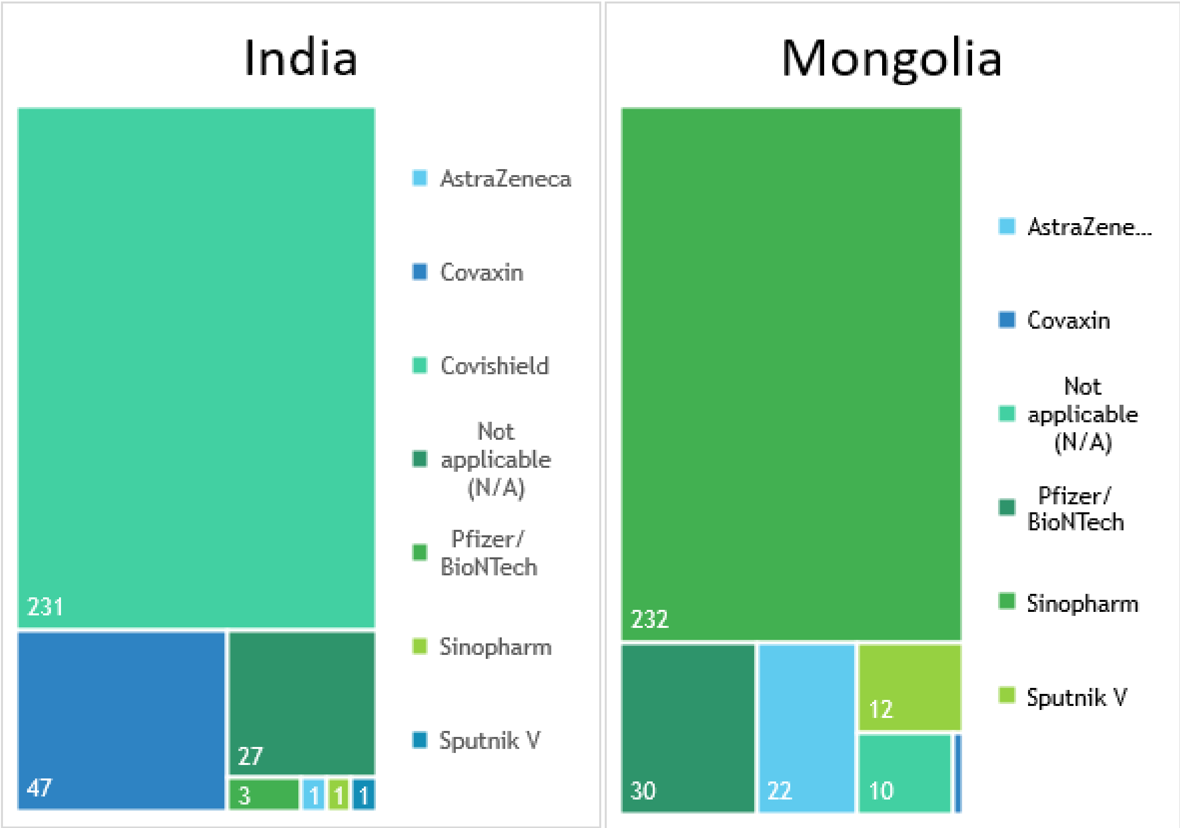


*Figure 12: Vaccine administered among the respondents in India and Mongolia*

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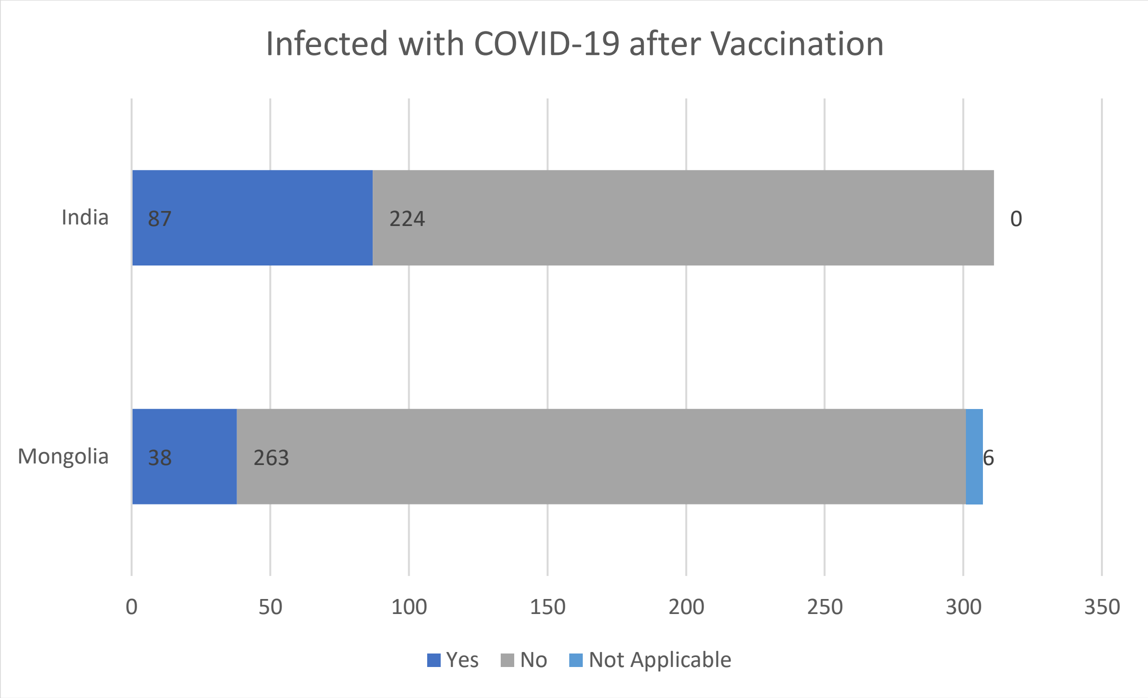


*Figure 13: COVID-19 infection after Vaccination*

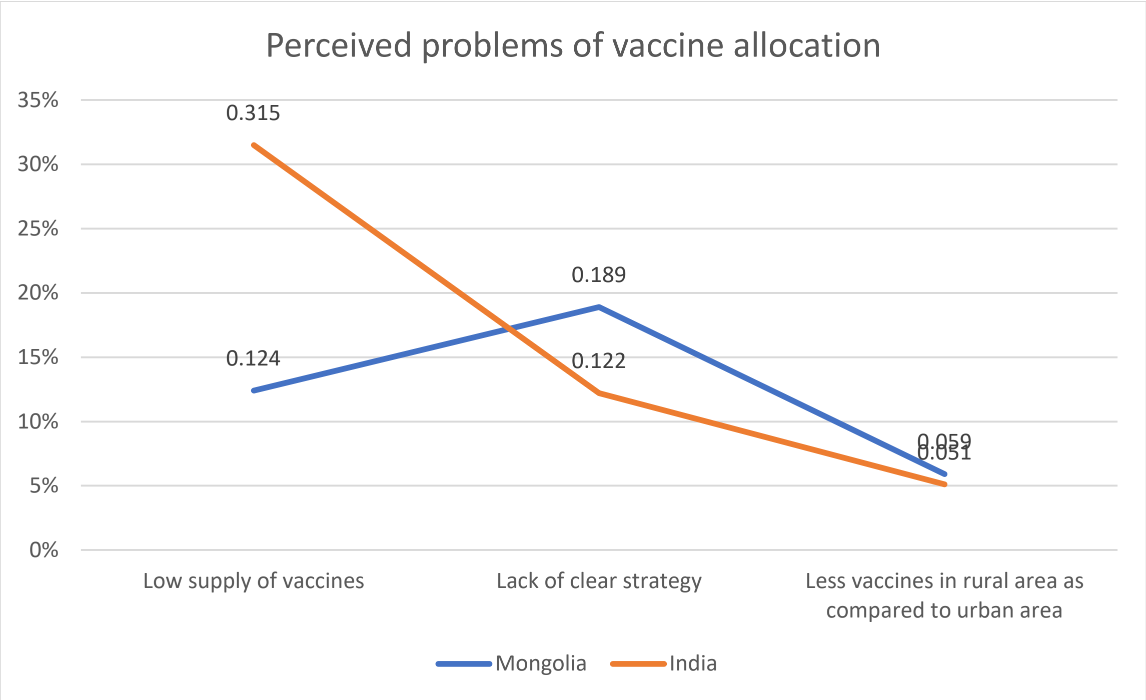


*Figure 14: Major Problems in Vaccine Distribution*

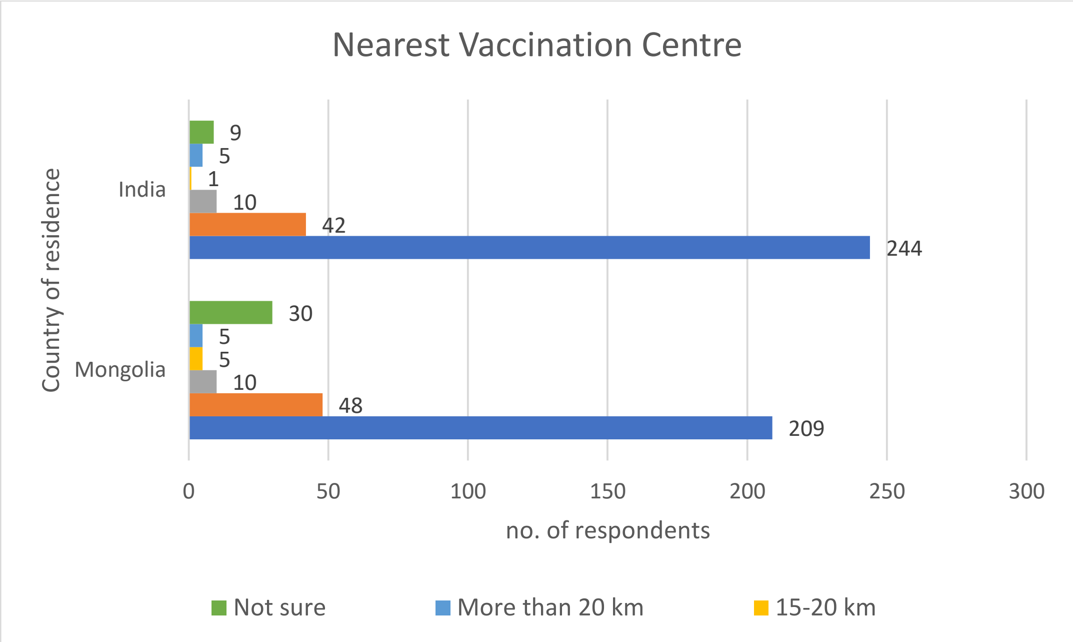


*Figure 15: Nearest vaccination centre*

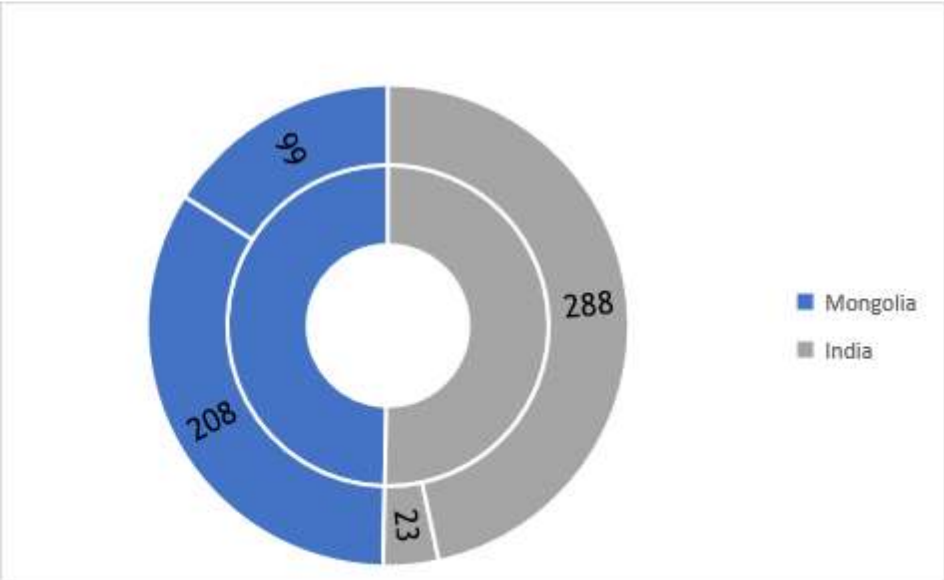


*Figure 16: Respondents admitting Distance from Vaccination centre as an obstacle*

 

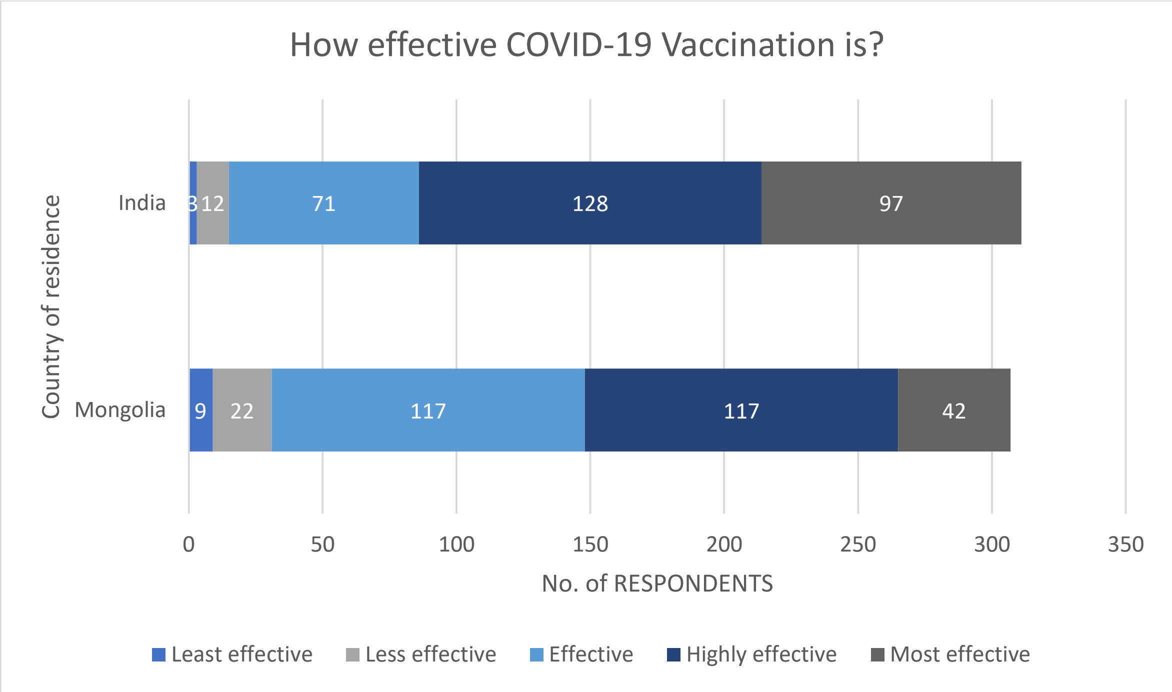


*Figure 17: COVID-19 vaccine effectiveness as per respondents*

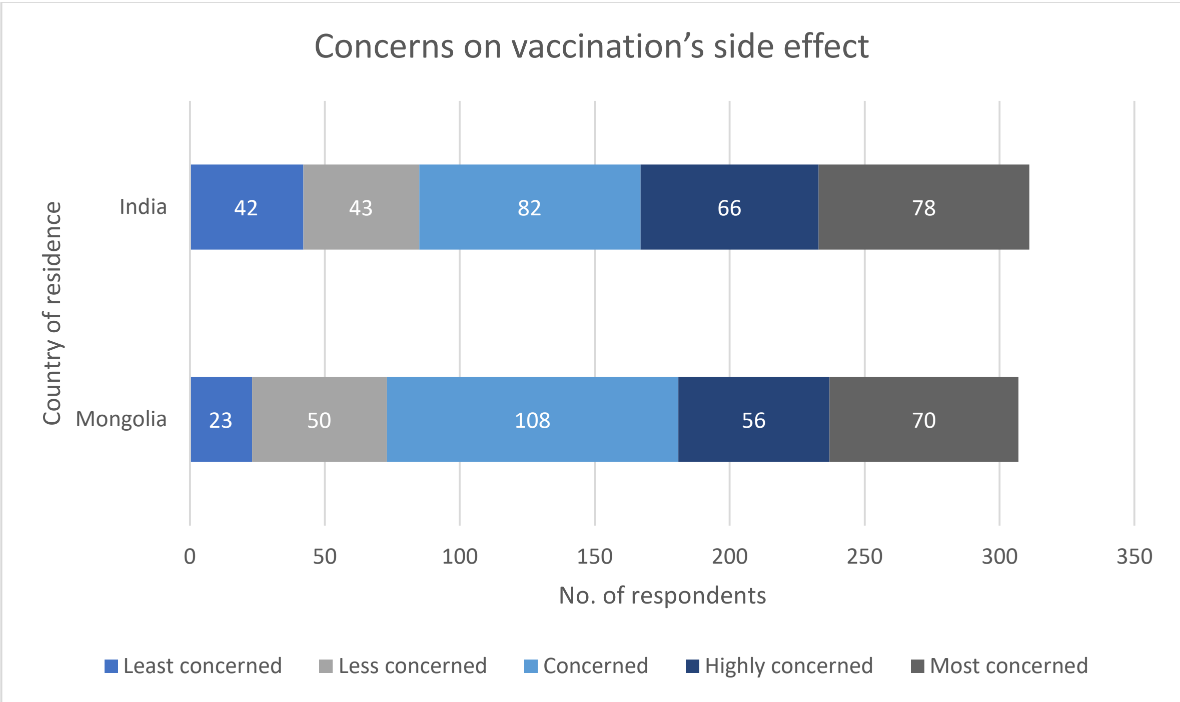


*Figure 18: Respondents with their concerns over vaccine side effects*

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 60% in India and Mongolia, respectively) (Table 3). About 23% of the respondents in Mongolia and 25% of the respondents in India are most concerned about the vaccine's side effects (Figure 18). For the majority of respondents in both India (78%) and Mongolia (67%), the distance from their location to the vaccination centres was less than 5 km (Figure 15). Individually, the distance from vaccination centers was not a major obstacle in both the countries (Figure 16). However, a logistic regression analysis showed a significant influence of the variables, country and type of settlement (Urban/ Rural) on distance from a vaccination center as an obstacle for getting the COVID-19 vaccine ($\chi2$ (10) =73.43, p<0.001). The model explained 17.8% variance on the dependent variable 'Vaccination centre distance as an obstacle (Negelkerke R2) and was able to identify 80.4% of cases accurately. The results show that for every unit increase in the variables 'Country of residence' and' Urban/ Rural' setup, the odds for having distance from the vaccination centre as an obstacle are 0.195 and 0.603 times respectively (Table 4). A Pearson Chi-Square test statistic ($\chi2$ (1) =7.246, P=0.007) suggested a significant association between distance from the COVID-19 vaccination center and type of settlement (rural/urban) of Mongolia, (Table 5), but the same was not significant for India ($\chi2$ (2) =1.125, p=0.570). A Spearman's rank order Correlation (Rho) suggest a significant positive correlation between the type of settlement (Rural/ Urban) in India and the COVID-19 Vaccination status ($\rho$=0.196, p=0.000) (Table 6), but the same was not significant for Mongolia ($\rho$=-.023, p>0.05). Also, the correlations show insignificant relationship between the variable, type of settlement (Rural/ Urban) versus the variables 'Vaccine is essential for combatting the COVID-19 Pandemic', 'Rating of effectiveness of vaccine', and 'Safety concerns regarding COVID-19 Vaccine' individually in both the countries. However, comprehensively, Spearman's rank order Correlation (Rho) shows a significant positive correlation between 'type of settlement' and 'Rating of effectiveness of vaccine' ($\rho$=0.086, p=0.033) (Table 7) and also a significant negative correlation between the type of settlement and vaccination is essential for combatting the COVID-19 Pandemic ($\rho$=-0.081, p=0.045) (Table 8). There was no significant correlation between the Level of education and the variables, 'Vaccine is essential for combatting the COVID-19 Pandemic', 'Rating of effectiveness of vaccine', and 'Safety concerns regarding COVID-19 Vaccine'.

*Table 3: Concerns regarding COVID-19 Vaccination*

| **India** | **Respondents (%)** | **Mongolia** | **Respondents (%)** |
|---|---|---|---|
| Lack of information about vaccines' side effects, safety and effectiveness | 35% | Lack of information about vaccines' side effects, safety and effectiveness | 60% |
| Lack of information about vaccines' side effects, safety and effectiveness,<br>Disbelief in vaccination in general | 11% | Lack of information about vaccines' side effects, safety and effectiveness,<br>Lack of trained human resources (nurses, doctors, paramedics etc.) to carry out the process | 12% |
| Disbelief in vaccination in general | 10% | Lack of trained human resources (nurses, doctors, paramedics etc.) to carry out the process | 7% |

*Table 4: Logistic regression between the mentioned independent variables and dependent variable 'Is distance from vaccination centre an obstacle for getting the COVID-19 Vaccine?'*

| 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 $\chi^2$ (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 5:Pearson Chi-Square test (Type of settlement (Urban/ Rural) versus 'Is distance from the vaccination centre an obstacle for getting the 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 6:Spearman's rank order correlation (Type of settlement (Urban/ Rural) versus COVID-19 Vaccination status in India)*

| | | | Type of settlement | COVID-19 Vaccination status |
|---|---|---|---|---|
| Spearman's rho | Type of settlement | Correlation Coefficient | 1.000 | .196** |
| | | Sig. (2-tailed) | . | 0.000 |
| | | N | 311 | 311 |
| | COVID-19 Vaccination status | Correlation Coefficient | .196** | 1.000 |

 

| | | | | |
|---|---|---|---|---|
| | | Sig. (2-tailed) | .000 | . |
| | | N | 311 | 311 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

*Table 7: Spearman's rank order correlation (Type of settlement (Urban/ Rural) versus Rating of effectiveness of COVID-19 Vaccine comprehensively in both countries)*

| | | | Type of settlement | How effective do you think the COVID-19 vaccine is? Please rate between 1-5. (1 = very bad, 5 = very good) |
|---|---|---|---|---|
| Spearman's rho | Type of settlement | Correlation Coefficient | 1.000 | .086* |
| | | Sig. (2-tailed) | . | .033 |
| | | N | 618 | 618 |
| | How effective do you think the COVID-19 vaccine is? Please rate between 1-5. (1 = very bad, 5 = very good) | Correlation Coefficient | .086* | 1.000 |
| | | Sig. (2-tailed) | .033 | . |
| | | N | 618 | 618 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | |

*Table 8: Spearman's rank order correlation (Type of settlement (Urban/ Rural) versus Vaccination is essential to combat the COVID-19 Pandemic comprehensively in both countries)*

| | | | Type of settlement | Vaccination is essential to combat the COVID-19 epidemic. |
|---|---|---|---|---|
| Spearman's rho | Type of settlement | Correlation Coefficient | 1.000 | -.081* |
| | | Sig. (2-tailed) | . | .045 |
| | | N | 618 | 617 |
| | Vaccination is essential to combat the COVID-19 | Correlation Coefficient | -.081* | 1.000 |
| | | Sig. (2-tailed) | .045 | . |

 

| | | | | |
|---|---|---|---|---|
| | epidemic. | N | 617 | 617 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | |

**Vaccine Modeling:**

After conducting vaccine modeling using the critical vaccination coverage mathematical model and the Silica application, the following results were obtained. Calculation of the critical vaccine coverage in India yielded 0.305 using *Equation 1*. The result obtained is shown in *Equation 3*.

$$v_c = E^{-1}(1 - \frac{1}{R_0}) = (0.9)^{-1}(1 - \frac{1}{1.379}) = 0.305 \text{ ……………………………… } \textit{Equation 3}$$

By this calculation, India would need to vaccinate around 30.5% of the population to achieve critical vaccination coverage. As of July 31, 2021, India had fully vaccinated approximately 7.55% of their population (Ritchie et al., 2021), leaving a further 22.95% of the population that needs to be vaccinated to achieve critical vaccination coverage. Taking into consideration the 95% confidence interval for $R_0$, the lower bound for India's critical vaccination coverage percentage was 30.3% (0.303) and the upper bound was 0.308 (30.8%).

Calculation of the critical vaccine coverage in Mongolia yielded 0.574 using *Equation 1*. The result obtained is shown in *Equation 4*.

$$v_c = E^{-1}(1 - \frac{1}{R_0}) = (0.54)^{-1}(1 - \frac{1}{1.45}) = 0.574 \text{ ……………………………… } \textit{Equation 4}$$

By this calculation, Mongolia would need to vaccinate around 57.4% of the population to achieve critical vaccination coverage. As of July 31, 2021, Mongolia had fully vaccinated approximately 60.49% of its population (Ritchie et al., 2021). Taking into consideration the 95% confidence interval for $R_0$, the lower bound for India's critical vaccination coverage percentage was 43.8% (0.438) and the upper bound was 0.994 (99.4%).

Mongolia had already achieved critical vaccination coverage as of July 31, 2021. To reach critical vaccination coverage, India will still need to vaccinate ~22.95% of the adult population (944 million people), which is 216,648,000 people. Each person should get two doses, so approximately 433,296,000 doses are required to reach this threshold. To reach this target percentage by December 31, 2021, India will need to administer approximately 2,850,000 vaccination doses a day between August 1, 2021 and December 31, 2021. As of July 31, 2021, India was administering approximately 5,100,000 doses a day (Bhatia et al., 2021). As India is administering nearly double the required number of doses needed to achieve critical vaccination coverage by December 31, 2021, it will hypothetically be able to reach critical vaccination coverage by October 31, 2021, as by this time, India will have administered approximately 464 million doses, around 31 million doses more than the critical vaccination coverage threshold. Assuming India continues to administer ~5,100,000 doses a day, while taking into consideration the 660 million vaccine doses India currently has on order (which they expect to last until December 31, 2021) and the 10 million doses the Indian government has said it will receive per day, there will not be a sufficient vaccine stock as required to vaccinate India to the critical vaccination coverage percentage by October 31, 2021. Figure 20 shows there will be around 383,000,000 doses in stock by October 31, 2021 taking into account this initial, one-time order of doses at the end of July, but 433,296,000 doses are required. Two options can be taken to remedy this: (1) increase manufacturing in-house to ensure that more doses are delivered to public and private hospitals each day, or (2) reduce the number of doses administered per day to ensure that a sufficient stock of vaccines will be available as India nears critical vaccination coverage towards the end of 2021.

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In India, the major two vaccines that have been used are Covishield with an average efficacy of 73% after the first dose and Covaxin with an average efficacy of 70% after the first dose (Table 9). As of June 20, 2021, Mongolia vaccinated 52% of its population with Sinopharm which has an average efficacy rate of 78% even after the second dose (Table 9). Estimations for the number of second doses in India or first doses in Mongolia were not calculated due to a lack of availability regarding efficacy rates for these administrations, as seen in Table 9.

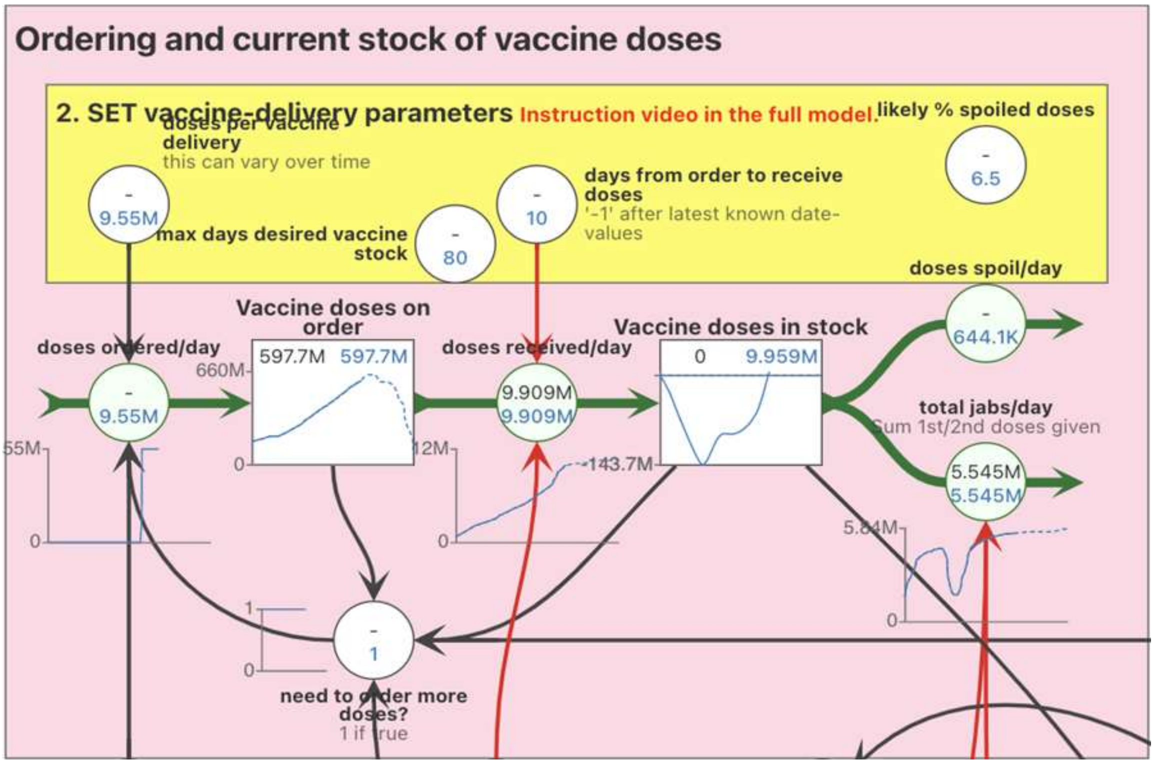


*Figure 19: Vaccination distribution pipeline in India as of July 31, 2021*

 

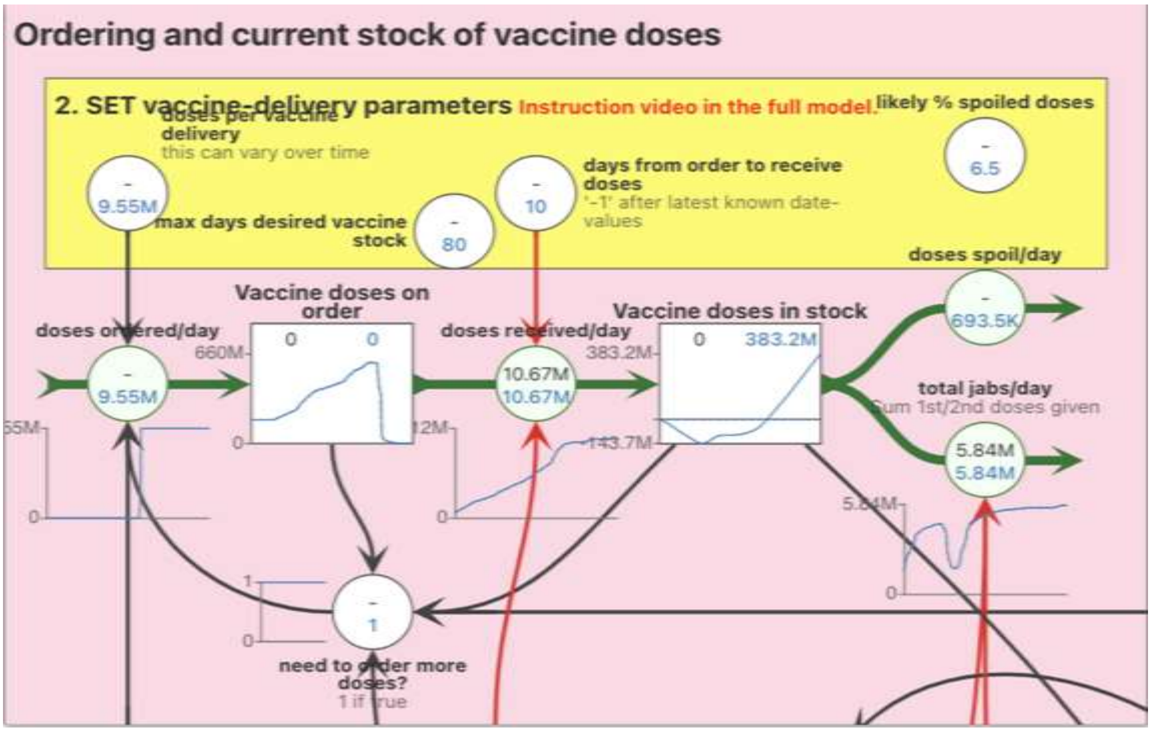


*Figure 20: Vaccination distribution pipeline in India as of October 31, 2021*

*Table 9[5]: Approved vaccinations and their respective efficacies in Mongolia (Sinopharm) and India (Covaxin, Covishield).*

| Efficacy of Approved Vaccinations in India and Mongolia | | |
|---|---|---|
| | Protection against all symptomatic disease after 1st dose | Protection against all symptomatic disease after 2nd dose |
| Covaxin | 70% | N/A |
| Sinopharm | N/A | 78% (65%-86%) |
| AstraZeneca (Covishield) | 73% (56% - 83%) | 67% (57% to 74%)** |

*Table 10[6]: Estimation of vulnerable population in India after receiving the first dose of either the Covishield or Covaxin vaccination*

| India | | | | |
|---|---|---|---|---|
| | Percentage of total doses administered | Number of First Doses Administered | No. of Vulnerable People after taking 1st dose | Percentage of Vulnerable People |
| Covishield | 87.42 | 38,56,23,645 | 104,118,384 | 26% |
| Covaxin | 12.46 | 5,49,63,059 | 16,488,917 | 30.00% |
| Total | 99.88 | 44,11,16,044 | 120607301 | |

[5] Ghosh, P. (2021, April 25). *Covaxin vs Covishield: Open-market price, EFFICACY, second-dose timing*. Hindustan Times. https://www.hindustantimes.com/india-news/covaxin-vs-covishield-open-market-price-efficacy-second-dose-timing-101619316091524.html.
[6] **Sources:** https://geographicinsights.iq.harvard.edu/IndiaVaccine and https://dashboard.cowin.gov.in/

*Table 11[7]: Estimation of vulnerable population in Mongolia after receiving the second dose of the Sinopharm vaccination*

| Mongolia | | | | | |
|---|---|---|---|---|---|
| | Percentage of population | Number of Doses Administered | Number of fully vaccinated People | No. of Vulnerable People after taking 2nd Dose | Percent of Vulnerable People |
| Sinopharm | 52% (approx) | 2,205,105 | 1,102,552 | 242,561 | 22.00% |

Our results show that, in India 120,607,301 are vulnerable after taking only the first dose of Covishield and Covaxin which is 26% and 30% respectively (Table 10), whereas in Mongolia, 22% (242,561) people are still vulnerable even after receiving their second dose (Table 11).

The results from a recent survey on the vaccination situation in Mongolia conducted by the National Statistical Office (NSO) of Mongolia supports our results. (B.Enkhtuya, 2021). Their survey results show that as of 5 July, 35.5 percent of all reported COVID-19 in the country were people who had been vaccinated. The report reveals that 27.9 of those confirmed with coronavirus were fully vaccinated whilst 7.6 percent of them have received the first doses; the remaining 64.5 percent were unvaccinated.

## 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 and distribution strategies might be something very different from India’s. However, 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 USAID to Mongolia of $450,000 or around $1.3 billion tughrik (Mongolian currency) was provided for COVID-19 relief. India’s efforts with vaccine distribution 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 and critical vaccination coverage mathematical model showed that Mongolia has already achieved critical vaccination coverage, effectively decreasing viral

[7] **Source:** Bhatia, G., Dutta, P. K., & McClure, J. (2021, August 15). *Mongolia: The Latest CORONAVIRUS counts, charts and maps*. Reuters. https://graphics.reuters.com/world-coronavirus-tracker-and-maps/countries-and-territories/mongolia/.

infection rates (though not completely, as only ⅔ of the population have been vaccinated thus far). However, India has not yet reached this threshold, despite starting vaccination allocation a little over a month earlier than Mongolia (January 16, 2021 versus February 23, 2021). There are two potential policies that would alleviate the aforementioned issue regarding a lack of vaccination supply in India. The first option is to increase manufacturing in-house and government or private-sector public health leaders should ensure timely delivery of doses, as 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). The second option is to reduce the number of doses administered per day to approximately 2 million; by this method, critical vaccination coverage will be reached by December 31, 2021 rather than October 31, 2021, but hospitals will be able to ensure they are able to build up a sufficient vaccine stock. When considering the second option, the vaccination rate should be increased or decreased according to the number of doses being delivered, such that the spoilage rate of vaccines is minimized, especially in states where it is over 11% (Andhra Pradesh, Telangana, etc.) as vaccination spoilage due to a large stock and low vaccination rate does not help vaccination distribution. The first option is the most advisable, considering the new Delta variant is 40% - 60% more transmissible than the Alpha strain of COVID-19 (Hagen, 2021), and prolonging vaccine distribution increases the population's susceptibility to infection. However, as this is a simulation and not based on the current manufacturing situation in India, the first policy option may not be possible, hence the second option serves as an alternative response. 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 which to receive vaccine doses should be considered in vaccination distribution policies. Increasing any one of these factors has a positive effect on the vaccination distribution 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.

Our findings also indicate that a portion of the population in both countries remains vulnerable even after receiving one or both doses of the COVID-19 vaccination. One of the key reasons for this could be the vaccines themselves (Orgel and Schaffner, 2021; Wee, 2021). The doses provided by China to Mongolia in recent months may not be very effective in containing the coronavirus disease, especially when faced off against the new virus variants that have triggered outbreaks in regions around the world. Others referred to the scarcity of data that emerges out of China, be it the clinical trials for the vaccines or efficacy and safety results (Hindustan Times, 2021). Furthermore, Nikolai Petrovsky, a professor at the College of Medicine and Public Health at Flinders University in Australia, said that with all of the evidence, it would be reasonable to assume the Sinopharm vaccine had minimal effect on curbing transmission. He said that a major risk with the Chinese inoculation is that vaccinated people may have few or no symptoms and still spread the virus to others (Wee, 2021). The implications of these findings of the vulnerable population along with the statistics from Mongolia's survey suggest that in the future, more people will be vulnerable to COVID-19 infections in Mongolia. Therefore, action must be taken to reduce the current cases in Mongolia and to potentially avoid another severe wave of COVID-19 infections. One possible way to avoid this can be through booster shots.

Previous surveys regarding COVID-19 vaccination perception have found that vaccination hesitancy plays a major role in whether or not an individual receives the COVID-19 vaccination. One such study aimed to understand vaccination hesitancy and associated factors among Indian medical students (Jain et al., 2021). An online survey was filled out by 1,068 medical students across 22 states in India between February 2, 2021 and March 7, 2021 (Jain et al., 2021). Vaccine hesitancy was found in 10.6% of survey respondents, as they responded "disagree" or "not sure" when asked if they would take the COVID-19 vaccination when offered (Jain et al., 2021). Additionally, there was a declining trend in vaccination hesitancy based on cumulative survey results, with vaccination hesitancy being 15.5% at the end of the first week and reaching the aforementioned 10.6% by the end of the fifth week (Jain et al., 2021). Those who were hesitant to take the COVID-19 vaccination identified that they obtained information about COVID-19 vaccination from social media, while those who were more accepting towards the vaccine received their information from teachers at their medical college (Jain et al., 2021). Another study aimed to assess current knowledge, perceptions, and concerns regarding COVID-19 vaccination in India through eight focus group discussions (Kumari et al., 2021). This study found that the level of knowledge or education did not correlate with vaccination perception in both hospital-based groups and groups of the general population (Kumari et al., 2021). Additionally, concerns contributing to negative attitudes regarding vaccine hesitancy were preference for natural immunity, misinformation, and fear of side effects (Kumari et al., 2021).

The results of the survey shows that there are not many 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 vaccine accessibility. The results of the survey have the potential to devise necessary policy interventions. A vaccination awareness campaign will provide the necessary information regarding vaccination side effects, safety, and effectiveness that was indicated as lacking in both countries per the survey responses. Further, there is a high need for regularly rolling out innovative campaigns without ignoring the rural areas. Additionally, increasing vaccination stock and providing a clear and direct vaccination distribution strategy will assist with the other issues mentioned in both countries (a low supply of vaccines and a lack of clear strategy). The modeling analysis also supports this conclusion. However, it is surprising that about 18.9% of the Mongolian respondents in the survey thought there was a lack of clear strategy in vaccine distribution as Mongolia has had a very successful vaccination distribution strategy so far. Additionally, methods such as the aforementioned mobile vaccination centers in Mongolia should be implemented in India. As indicated by the survey results, distance from a COVID-19 vaccination center was significantly impacted by a rural versus urban settlement in Mongolia. Despite this, since Mongolia is more sparsely populated than India and therefore has fewer congregated populations where vaccines can be easily mass-administered, it is likely that it was able to vaccinate more individuals than otherwise possible due to the aforementioned mobile vaccination centers implemented there, which brought vaccinations to rural populations who may not otherwise. If a similar method is used in India to bring vaccinations to rural populations, India will be able to significantly increase their vaccination coverage.

Limitations to this study include that the survey sample did not equally represent all aspects of the population in both countries. Since India’s population is over 421 times larger than that of Mongolia (Worldometer, 2021), our sample size may not be representative of the vast population difference between the two 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. This could introduce a potential gender or regional bias that should be eliminated. There was also a lack of public data surrounding vaccine administrations per day for different priority groups, which greatly 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.). Although both Mongolia and India are developing countries, the climate under which clinical and vaccination trials take place in both locations is also bound to differ. Public perception regarding the vaccine, development of scientific research, daily number of COVID-19 cases, rate of clinical trials, vaccination availability, etc. are all extraneous variables that could serve as potential restrictions to the findings and implementation of a vaccine distribution plan. Strengths of this study include the comprehensive three-pronged approach that was taken to effectively analyze the vaccine allocation and distribution 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.

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| Annexure I | |
|---|---|
| **Section I: Questions Regarding Demographics (Profile Characteristics)** | |
| **Question (Parameter)** | **Answer-Choice Options** |
| Country of residence. | a) India<br>b) Mongolia |
| Type of settlement. | a) Rural<br>b) Urban |
| Please select your gender. | a) Male<br>b) Female<br>c) Prefer not to answer |
| Enter your age. | Open ended (enter a number). |
| Select the highest level of education you are pursuing or have completed. | a) School education<br>b) Diploma<br>c) Undergraduate<br>d) Postgraduate<br>e) Doctorate/ MPhil/ DPhil |
| **Section II: Questions Regarding COVID-19 Vaccination Perception** | |
| **Question (Parameter)** | **Options** |
| Are you aware about COVID-19 vaccination? | a) Yes<br>b) No |
| How did you come to know about COVID-19 vaccination? (Select all that apply.) | a) News channels (TV, radio, newspaper, etc.)<br>b) Doctors<br>c) Friends/ family/ neighbors<br>d) Social media (WhatsApp, Facebook, Twitter, etc.)<br>e) Government's trusted site |
| Vaccination is essential for fighting the COVID-19 pandemic. | a) Strongly agree<br>b) Agree<br>c) Don't know<br>d) Disagree<br>e) Strongly disagree |
| Are you willing to take the vaccine when available/ have you already taken the vaccine? | a) Yes<br>b) No<br>c) Maybe/ not sure |
| Which of these options describes your COVID-19 vaccine status? | a) Received only first dose<br>b) Received two doses<br>c) Scheduled to receive first dose<br>d) Scheduled to receive second dose<br>e) No/ don't want to take the COVID-19 vaccine even if available |
| Which COVID-19 vaccine did you take? | a) AstraZeneca<br>b) Covishield<br>c) Covaxin<br>d) Sputnik V<br>e) Sputnik Light<br>f) Moderna<br>g) Pfizer-BioNTech<br>h) Sinopharm<br>i) Not applicable (NA) |
| What do you think are the problems with vaccine allocation in your region? (Select all that apply.) | a) Low supply of vaccines<br>b) Poor vaccine distribution in sub-regions<br>c) Vaccination centers are too far away<br>d) Corruption<br>e) Fewer vaccines in rural areas as compared to urban areas<br>f) Lack of clear strategy<br>g) Other (specify, if any) |

| | |
|---|---|
| How far away is the nearest COVID-19 vaccination center? | a) <5 km<br>b) 5-10 km<br>c) 10-15 km<br>d) 15-20 km<br>e) 20+ km<br>f) Not sure |
| Is distance from a vaccination center an obstacle for getting the COVID-19 vaccine? | a) Yes<br>b) No |
| Did you get infected with COVID-19 after taking the first dose/ complete dose? | a) Yes<br>b) No<br>c) Not applicable (not taken any of the doses) |
| On a scale of 1-5 (1 = least, 5 = greatest), how effective do you think the COVID-19 vaccine is? | Respondents selected a value on the scale. |
| What are your major concerns regarding the COVID-19 vaccines? (Select all that apply.) | a) Lack of information about the vaccines, side effects, safety, and effectiveness<br>b) Lack of trained human resources (nurses, doctors, paramedics, researchers, etc.) to carry out the process<br>c) Fear of injection<br>d) Disbelief in vaccination in general<br>e) Religious/ cultural reasons or belief in traditional remedies |
| On a scale of 1-5 (1 = least, 5 = greatest), how concerned are you about the side effects/ safety concerns of the COVID-19 vaccine? | Respondents selected a value on the scale. |
| **Only in Mongolia:** What was your major driving force for getting vaccinated? (Select all that apply.) | a) Cash benefits<br>b) Access to indoor services and domestic travels<br>c) Protection of oneself<br>d) Protection of family |