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Survey on Vaccine Effectiveness and Covid- 19 Severity

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ABSTRACT: To combat covid-19 many vaccine candidates have been developed and vaccination campaigns are carried out around the world. The present study was planned to compare the effectiveness of the major covid-19 vaccines used in India and Sri Lanka. A survey was conducted among the Indian and Sri Lankan people of age above 18. Two doses of Covishield, Covaxin, and Sinopharm were found to have almost the same and high vaccine effectiveness. A booster dose is important for protecting against the omicron variant. Due to the limitations in employing face-to-face methods during an active outbreak, the majority of data were collected using the google form platform.As the data was collected through a survey among people, the CT values of the RT-PCR test of the infected individuals couldn't be collected, therefore the severity of the disease couldn't be considered in the study. This study provides insight into the vaccination status, the vaccine effectiveness of the majorly used vaccine in both India and Sri Lanka, the risk factors of covid-19, and the further measure to be taken to combat the pandemic.

Keywords: Booster dose, Covid-19, Survey, Vaccine effectiveness (VE).

INTRODUCTION

As of 8th July 2022, more than 558 million people have been infected with covid-19 with more than 6 million deaths worldwide. India has reported more than 43 million cases with 525,305 deaths and Sri Lanka has reported around 664,217 cases with 16,525 deaths from the start of the pandemic till the 8th of July.(https://www.worldometers.info/coronavirus/). The covid-19 pandemic caused by the SARS-CoV-2 virus has resulted in catastrophic consequences for the economy, education, and the health care system. Mutations in the spike protein of the virus have resulted in different variants. Fig. 1 shows the main structural proteins of the Sars-CoV-2 virus.

B.1.1.7(UK variant/ alpha strain), B.1.351 South African variant/beta strain), B.1.1.28.1 (Brazilian variant/ gamma strain), B.1.617.2 (delta variant), and B.1.1.529 (Omicron variant) are the variants that have become dominant (Roy *et al.*, 2021). B.1.1.7 has 23 mutations compared to the original strain. B.1.351 has 23 mutations and 17 amino acid changes compared to the original strain. B.1.1.28.1 variant has 35 mutations and 17 amino acid changes compared to the original strain. B.1.617.2, the delta variant that led to the deadly second wave of infection in India, has 5 mutations in the spike protein. Delta variant is considered more fatal as it is 60% more transmissible and has a greater chance of secondary attack. The new variant omicron B.1.1.529 has 32 mutations on the spike protein and it is 10 times more contagious than the original variant and 2.8 times more contagious than the delta variant (Roy *et al.*, 2021; Vasireddy *et al.,* 2021).

Coronavirus is a highly contagious virus that spreads through contact with respiratory droplets (Ahmad, 2020). Initially, preventive measures were taken to limit the spread of the virus such as wearing personal protective equipment, maintaining hand hygiene, social distancing, and quarantine (Güner *et al*., 2020; Ahmad, 2020). Screening of blood samples for antibodies against the covid-19 virus and detecting the viral DNA in sputum samples by polymerase chain reaction are the two main diagnosis methods available for covid-19 (Ahmad, 2020), (Zhai *et al.,* 2020). Till now none of the drugs are approved by the US Food and Drug Administration(FDA) for the treatment of patients infected with covid-19 (Lotfi *et al.*, 2020; Venkatasubbaiah *et al*., 2020). Therefore some already available drugs are recommended by the health care systems of different countries to be used for the treatment of covid- 19 (Venkatasubbaiah *et al.,* 2020). Favipiravir, chloroquine phosphate, remdesivir, hydroxychloroquine, lopinavir/ritonavir, theaflavin,

thalidomide, and arbidol are some of such medications used for treating covid-19 patients as per the suggestion of the health care system of specific countries (Salasc *et al.,* 2022; Venkatasubbaiah *et al.,* 2020; Havare, 2021). Fully vaccinating the majority of the world's population is a critical step in eradicating the covid- 19 pandemic (Rashedi *et al.,* 2022). Several vaccine candidates have been developed around the world. As of 1st April 2022, 196 vaccines were under pre-clinical development and 153 vaccines were under clinical development (https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines).

Pfizer/BioNTech: Comirnaty(BNT162b2),Moderna: Spikevax(mRNA-1273), Janssen (Johnson & Johnson): Ad26.COV2.S, Oxford/AstraZeneca: Vaxzervria (ChAdOx1 nCoV-19), Serum Institute of India: Covishield (Oxford/ Astra Zeneca formulation), Bharat Biotech: Covaxin(BBV152), Sinopharm (Beijing): Covilo, Sinovac: CoronaVac, Serum Institute of India: COVOVAX (Novavax formulation), Novavax: Nuvaxovid(NVX-CoV2373) are some of the vaccines that are approved by WHO for emergency use(https://covid19.trackvaccines.org/agency/who/) (Ndwandwe & Wiysonge, 2021; Rashedi *et al.*, 2022).

Disapproval of specific vaccines by some countries, difficulty in supplying vaccines to poor countries, vaccine hesitancy among several people, and the emergence of new variants are the main challenges to the vaccination program (Rashedi *et al*., 2022; Mohamed *et al.*, 2022). Some studies have explored the effectiveness of the currently available vaccines against different variants of covid-19 and they have shown that the effectiveness of a particular vaccine varies for different variants of the coronavirus. A population-based study in New York state has shown a decline in vaccine effectiveness, especially among the age group 65 and older with the prominence of the delta variant (Rosenberg *et al*., 2022). A study done in Ontario, Canada states that 2 doses of the covid-19 vaccine provide only short-term protection against symptomatic omicron infection and the third dose of covid-19 improves the protection against omicron variant and provides excellent protection against severe outcomes for both omicron and delta variants (Fell *et al.*, 2022).

A study thatwas done in England to measure the effectiveness of Oxford- AstraZeneca, and Pfizer has stated that primary immunization with 2 doses of the above vaccines provided no or limited protection against omicron variant but there was a significant increase in the effectiveness of the above vaccines againstthe omicron variant with the booster dose (Andrews *et al.,* 2022).

Knowing about the vaccination status of the population, the effectiveness of the currently available vaccines on different Sars-CoV-2 variants, and other sociodemographic and risk factors affecting the covid-19 severity is important to take further measures to control the pandemic. Many studies have been conducted to assess the effectivenessof majorly used vaccines so far. These studies have been restricted to a single country, a specific region (Singh *et al.*, 2021), or an individual vaccine (Pramod *et al*., 2022). But a real-world study to compare the effectiveness of the major vaccines used among the Indian and the Sri Lankan populations along with the risk factors affecting the covid-19 infection has not been done yet.

Through this study, we sought to assess the vaccination status of the Indian and the Sri Lankan population, identify the sociodemographic characteristics and risk factors associated with covid-19 infection, and study and compare the vaccine effectiveness of themajorly used vaccine types in India and Sri Lanka and identify the best vaccine available for the prevention of covid-19 in the South Asian region by conduction a survey among the people.

MATERIALS AND METHODS

This cross-country study was conducted from 06th February 2022 to 13th March 2022. The target participants were Indian and Sri Lankan adults aged 18 years and above who could read and understand English. Due to the limitations in employing face-to-face methods during an active outbreak, the data were collected using the Google Forms platform via an online questionnaire, and also a few printed forms were handedover to the people in areas where the cases were to the minimum or zero. A snowball sampling strategy was used to distribute the online questionnaire via social media (WhatsApp, Facebook, Instagram). First, few primary recipients were recruited. The participants were then asked to share the questionnaire link with individuals in their social circles (aged 18 years and above). The social media platforms were chosen because they are widely used among the Indian and Sri Lankan populations across sociodemographic characteristics.

Questionnaire on COVID-19 vaccine: efficacy. The survey consisted of 22 questions covering sociodemographic characteristics (Questions 1 to 5), information regarding COVID-19 vaccination (Questions 6 to 13), medical illnesses (Questions 14 to 19), where abouts, and employment (Questions 20 to 22). Questions 14 to 19 were only answered by those who were infected with the COVID-19 virus during the outbreak.

Sociodemographic characteristics (Questions 1 to 5) included Gender, Age group, Country of residence, State/ province, and zip code. Information regarding the COVID-19 vaccination (Questions 6 to 13) included the vaccination status of the individual, the number of vaccine doses received, and the date of vaccination. Questions regarding the booster dose (the vaccine type and the date of vaccination) were also included. The questions regarding the booster dose were optional

considering that most people have not been provided with the booster dose at the time of the survey. Questions 14 to 19 included questions based on whether the person has been infected with the COVID-19 virus or not. If yes, then they were asked about the date of infection, the variant of the covid-19 that they were infected with,and the CT value of the RT-PCR test. The next few questionswere about their health conditionand employment.Questions 20 to 22 were regarding the location of the person during the pandemic and whether they have traveled to some other country at the time of the pandemic.

Data analysis. All the responses collected through the survey were entered into the Microsoft Excel sheet. Analysis of the data was done manually using the excel tools and the statistical pie charts that were created from all the responses that we received in the survey.

RESULT AND DISCUSSION

Demographic data. A total of 406 respondents participated in the survey. Out of them, 7 responses were rejected due to incomplete answers. 75.93% (n=303) of the participants were from India and 24.06% (n=96) of the participants were from Sri Lanka. 53.13% (n=212) were females and 46.86% (n=187) were males. Almost half of the respondents were of the age group 20-30 (49.62%, n=198) and the age group above 80 was the minority (1.7%, n=7). Figures 2, 3, and 4 show the sociodemographic data of the respondents.

Vaccination status. Out of the 406 respondents, 77.69% (n=310) of the respondents have been fully vaccinated with 2 doses, 7.76% (n=31) have been vaccinated with only one dose, 12.78% (n=51) have received two doses with the booster dose and 1.7% (n=7) have not been vaccinated. Out of the Indian respondents, 89.43% (n=271) have been vaccinated with 2 doses, 6.6%(n=20) have beenvaccinated with only one dose and 3.3% (n=10) have received the booster dose. Out of the Sri Lankan respondents, 40.62% (n=39) have been vaccinated with 2 doses, 11.45% (n=11) have been vaccinated with only one dose and 42.7% (n=41) have received the booster dose. Table 1 shows the vaccination status of the respondents from each country.

As of 6th July 2022, 66.5% (917.7million) of the Indian population has been fully vaccinated and7.15% (99.58 million)have been partly vaccinated with one dose and in Sri Lanka, 67.62% (14.54 million) of the population has been fully vaccinated and 11.81% (2.54 million) have been partly vaccinated with one dose as of 20th June 2022 (https://ourworldindata.org/covid-vaccinations?country=IND~LKA). The people who have received more than one dose are considered fully vaccinated. The high percentage of vaccination in our data is due to the less number of respondents and coverage of only certain geographical areas of each of the countries. The overall majority of the individuals have been fully vaccinated in both India and Sri Lanka.

Types of vaccines received. The respondents have been administered with various types of vaccines such as Covishield, Covaxin, Sinopharm, Moderna, Pfizer, and sputnik. The majority of them have received Covishield (54.88%, n=219) and AstraZeneca is the vaccine that is received by the least number of respondents (0.8%, n=3). 10 covid vaccines have been approved for use in India, but Covishield and Covaxin are the mostly used vaccines. According to the data collected from the survey, 71.61% (n=217) of the Indian population has been administered with Covishield. As of February 2022, out of the 1.8 billion doses administered in India, 1.4 billion doses wereCovishield.
(https://www.statista.com/statistics/1248301/india-covid-19-vaccines-administered-by-vaccine-type/#statisticContainer).

Covishield is a non-replicating chimpanzee adenovirus vaccine vector that is developed by the Serum Institute of India in collaboration with the University of Oxford, UK, and pharma giant AstraZeneca, and Covaxin is an inactivated virus vaccine that is produced by Bharat Biotech in collaboration with the National Institute of Virology and the Indian Council of Medical Research(Kumar et al., 2021). Seven covid vaccines have been approved for use in Sri Lanka. The majority of the Sri Lankan respondents have received Sinopharm (40.62%, n=39) followed by Moderna (23.95%, n=23), Pfizer (17.70%, n=17), and Sputnik (7.29%, n=7).

Most people have been vaccinated with the same type of vaccine for the 1st and the 2nd dose. 80.39%(n=41) of the respondents have received Pfizer for the booster dose, and the rest were vaccinated with Covishield, Covaxin, and Sinopharm. Therefore the majority of the respondents have received Pfizer for the booster shot. Fig. 5 shows the types of vaccines received by the respondents.

Factors affecting covid-19 infection. The majority of the individuals who were infected with covid-19 belong to the 20-30 age group (67.85%, n=19) followed by 40-50(17.85%, n=5), 30-40, and below 20 (7.14%, n=2). The least percentage of individuals infected with covid-19 are in the age range of below 20 years (4%, n=2). According to the studies conducted in ten European countries about the covid 19 infection rates and age,it was found that the individuals between the age group 20- 59 have the greatest chance of infection with a percentage of 56.7, and the age group 0- 19 has the least chance of infection which is 4.3% (Sobotka *et al.,* 2020). Increased age has been suggested as a risk factor for covid-19 infection as the disease severity, hospitalization, and the number of deaths were found to be high among senior citizens compared with the others (Starke *et al*., 2020).

Out of the cohorts infected with covid- 19 around 57.14% (n=16) are males and 42.85% (n=12) are females. This shows the infection rate is slightly higher for men than women. Studies suggest that the reason for the lower infection rate in women is due to the presence of estradiol in high concentrations in women. Estradiol increases the expression and activity of A disintegrin and metalloprotease 17 protein, which increases the amount of ACE2(Angiotensin- Converting Enzyme 2) that blocks the entry of Sars-CoV-2 (Rashedi & Asgharzadeh, 2020). Some studies suggest that both men and women are equally susceptible to covid-19 but the severity and fatality of covid-19 are higher for men than for women (Mukherjee & Pahan 2021). Table 2 shows the information of the respondents who were infected with covid-19.

6.01% (n=24) of the total respondents are working in the health care sector and 29.1% (n=7) of them were infected with covid-19. Out of the infected individuals working in the health care sector, 71.42% (n=5) were infected with covid-19 after being vaccinated with 2 doses and 28.5% (n=2) were infected with covid-19 before vaccination. Health care sector occupations are considered an environmental risk factor of covid-19 infection andhealthcare workers are considered the most vulnerable people to contact with the disease as the virus can spread quickly among the patients (Rashedi & Asgharzadeh 2020).

There are no complications reported in any of the respondents who were infected with covid-19. Severe obesity, diabetes, chronic kidney disease, dementia, HIV/AIDS, and working in health care, and primary care sectors are considered risk factors for the infection of covid-19 (Rashedi & Asgharzadeh 2020; Rod *et al*., 2020; Rozenfeld *et al*., 2020). Diabetes is one of the most critical comorbid conditions that are responsible for the severity of the covid-19 disease (Rod *et al.,* 2020).

Impact of vaccination on covid-19 infection rate. 7.0%(n=28) of the total respondents have been infected with covid-19. 53.57% (n=15) of them were infected before vaccination, 42.85% (n=12) were vaccinated with 2 doses at the time of infection and 3.57% (n=1) were infected after receiving one dose. Vaccination reduces the overall covid-19 infection rate and also decreases the adverse outcomes of covid-19 such as hospitalizations and deaths. A study conducted in the US during the third wave of the pandemic shows that a high number of covid cases were reported in areas with a lower rate of vaccination. (Moghadas *et al.,* 2021; Cuadros *et al*., 2022).

According to the data collectedfrom the survey, the vaccine effectiveness of Covishield, Covaxin, and Sinopharm after two doses is 96.34%, 96.96% and 94.75% respectively. A study done among the healthcare and frontline workers of the Indian Army shows 91.8–94.9% vaccine effectiveness for Covishield (Ghosh *et al.,* 2021). A test-negative case-control study done in Puducherry, India has shown 49% VE with one dose and 54% VE with two doses in protecting from covid-19, and 95% VE in moderately severe disease conditions for the same vaccine (Pramod *et al.,* 2022).

Covaxin shows 81% efficiency in preventing the Sars-CoV-2 infection as reported in March 2021 and it shows 69% effectiveness towards severe covid-19 infection (Behera *et al.,* 2022). Sinopharm shows 79% vaccine effectiveness against symptomatic covid-19 infection as reported by WHO and 100% VE against severe disease conditions (Ghiasi *et al.,* 2021). Studies conducted in UAE during the delta outbreak show 62% VE after partial vaccination and 95% VE after the full vaccination for Sinopharm (Ghiasi *et al.,* 2021).

According to our study, Covishield, Covaxin, and Sinopharm show almost the same vaccine effectiveness. The VE of all three vaccines is higher than the VE reported in previous studies conducted in India and UAE. High VE in our study might be due to many factors such as the difference in the most prevalent variant, decrease in the pandemic rate during our study period, comparatively smaller number of respondents, and the collection of responses from some specific regions.

According to the data collected, 32.14% (n=9) have been infected with SARS-CoV-2 variant, 28.27% (n=8) with deltavariant, and 10.71% (n=3) with omicron variant. Among the people who were infected with the Sars-CoV-2 variant, 33.33% (n=3) have been vaccinated with two doses of Covishield, and 11.11% (n=1) have been vaccinated with one dose of Covishield and 55.55% (n=5) have not been vaccinated. Therefore, a decrease in Sars-CoV-2 infection could be found after vaccination with two doses of Covishield.

Among the respondents who were infected with the delta variant, 62.5% (n=5) were not vaccinated, and 37.5% (n=3) were vaccinated with two doses of Covishield, Covaxin, and Sinopharm. The percentage of individuals infected with the delta variant after being vaccinated with 2 doses is much lower compared with the percentage of individuals infected before vaccination. This indicates that the covid-19 vaccines are effective against the delta variant. A study conducted in Guangdong, China during the outbreak of the delta variant states that the severity of the disease caused by the delta variant is reduced in fully vaccinated individuals compared with unvaccinated individuals (Kang *et al.,* 2022).

ChAdOx1 nCoV-19: Oxford AstraZeneca which is similar to Covishield is estimated to have a VE of 30% with a single dose and 67% with two doses against symptomatic infection with the delta variant (Lopez Bernal *et al.,* 2021). Covaxin has also shown effectiveness against alpha, beta, delta, kappa, and zeta variants (Edara *et al*., 2022).

Among the respondents of the survey, all the individuals who were infected with the omicron variant have been vaccinated with 2 doses but have not received the booster doseand it is also noticed that they were infected with the omicron variant 3-4 months after receiving the 2nd dose. None of the respondents who were vaccinated with the booster dose have been infected with the omicron variant. This indicates that 2 doses of vaccine are not sufficient to protect against the omicron variant and a booster dose is important for immunity against the omicron variant. Out of the respondents who have received Pfizer for the booster dose, 32.7% have been administered with Moderna, 28.8% with Sinopharm, 11.5% with Sputnik, and 3.8% with Covishield for the 1st and 2nd dose. Homologous and heterologous booster combinations are found to boost immunity against the omicron variant (Martin *et al.,* 2022).

The individuals who are vaccinated with 2 doses recently have higher vaccine effectiveness and it wanes with time. The percentage reduction of vaccine effectiveness after 2 doses is estimated to be higher for the omicron variant than that for the delta variant. But a significant increase in vaccine effectiveness is observed against the omicron variant after receiving the booster dose (Gardner & Kilpatrick 2021). Therefore administering the booster dose to the population is important to restore the vaccine effectiveness against the omicron variant and to control the pandemic(Hogan *et al*., 2022).

Limitations of the study. The data was collected by conducting a survey among the Indian and the Sri Lankan people. The individuals who were infected with covid-19 were not aware of the cycle threshold (CT) values of the RT-PCR testand therefore we were not able to consider the severity of the disease in the study. Moreover, the collection of data from some specific geographical regions and a lower number of respondents might have impacted some of the survey results such as high vaccine effectiveness compared to previous studies.

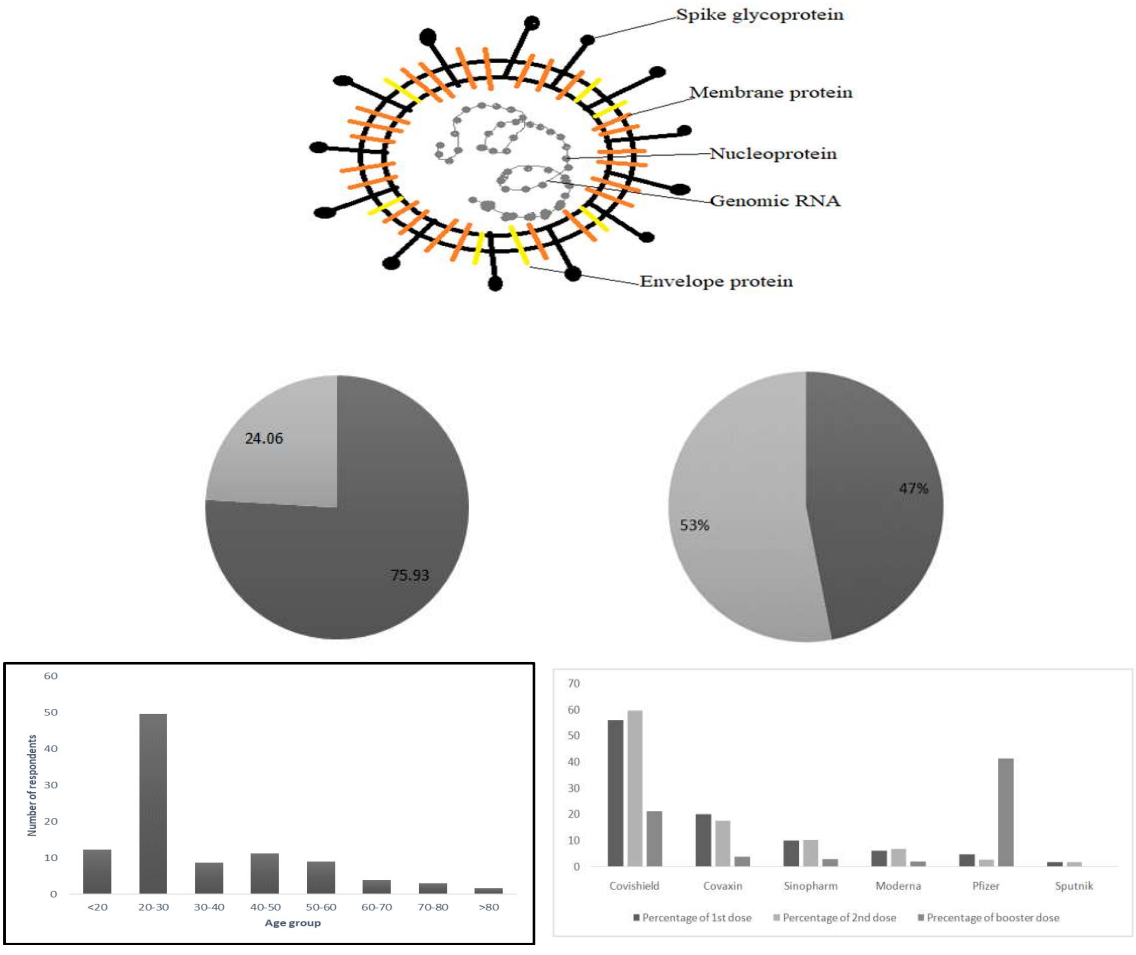

Table 1: Vaccination status of the respondents.

Vaccination status	Percentage of individuals from India	Percentage of individuals from Sri Lanka
Vaccinated with only one dose	6.6	11.45
Vaccinated with two doses	89.43	40.62
Vaccinated with two doses and the booster dose	3.3	42.7
Not vaccinated	0.6	5.2

Table 2: Information of the respondents who were infected with covid-19.

Factors	Percentage (%)
Age group	
Below 20	7.14
20-30	67.85
30-40	7.14
40-50	17.85
Gender	
Males	57.14
Females	42.85
Vaccination status	
Before vaccination	53.57
Between 1st and the 2nd dose	3.57
After both the doses	42.85
Covid- 19 variant	
Sars-CoV-2	32.14
Delta	28.27
Omicron	10.71

CONCLUSION

Covishield, Covaxin, and Sinopharm, which are the major vaccines used in India and Sri Lanka show almost equal and very high vaccine effectiveness against Sars-CoV-2 and delta variants. Covaxin and Covishield are the main two types of vaccines administered to the Indian population. Two doses of vaccine are not effective to protect against the omicron variant. But two doses and a booster dose are highly effective against all the covid-19 variants including omicron. This result corresponds to other studies done in different regions. Factors such as age, gender, environmental factors, and comorbid conditions affect the covid-19 infection rate. The vaccination drive has been unprecedented in both scale and reach. Vaccination plays an important role in reducing the severity, death, and infection rates of different variants of covid-19. According to our study, the majority of the population is fully vaccinated. But the number of individuals who have been administered the booster dose is comparatively less. Therefore, necessary steps should be taken to vaccinate the remaining population with the booster dose to overcome the pandemic.

FUTURE SCOPE

Our study has provided an insight into the vaccination status of the Indian and the Sri Lankan population and the importance of vaccination in controlling the pandemic. Most importantly the data collected has shown the necessity of a booster dose for protecting against the omicron variant. The findings of this study may therefore be helpful in overcoming the vaccine hesitancy among the general public and in boosting vaccination rates in Sri Lanka and India.

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Conflict of Interest. None.

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