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A Review on Current Vaccination Status of COVID-19 in Maharashtra State of India Using GIS

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Abstract

Coronavirus is spreading globally with an increasing rate of mortality. It is spreading in all state of India with different strains. Maharashtra is one of the most severely impacted states in India, having the highest number of COVID-19 (Coronavirus disease) cases. Currently, there is no effective treatment for COVID-19. As social distancing and all other preventive measures are very costly from both social and economic points of view. Therefore, vaccination is now only a critical new tool to make our immune system stronger in the battle against COVID-19. Using geo-visualization tools, this review article aims to investigate the present status of COVID-19 vaccination in Maharashtra, India. The current status is shown through compiled maps of district-wise vaccination by age, vaccination by gender, vaccine category, total vaccination doses, and total vaccination has done in Maharashtra till July 2, 2021. The collected COVID-19 vaccination data is processed for the required results. The special distribution map for a different parameter of the present study has been carried out using Arc GIS software. After processing and combining vaccination and geospatial data, we compiled and generated district-wise graduated colour maps of Maharashtra. This review article briefly covers the Introduction, vaccination and its importance, and district-wise COVID-19 vaccination status of Maharashtra. Some basic advice and suggestions to improve the vaccination rate are also covered. The data and outcomes presented in this review are susceptible to change over time.

Keywords: *COVID-19, Coronavirus, Covaxine, Covishield, GIS, Vaccination*

Introduction

The world is facing a big health crisis due to COVID-19 since one and half year. COVID-19 is a novel strain of coronavirus that causes an infectious illness (Kaushik et al. 2020) (Saurabh Shrivastava et al. 2021). People infected with COVID-19 suffer mild to moderate respiratory illness and recovered without taking any medical care, but people with other medical issues such as diabetes, cardiovascular disease, chronic respiratory disease, or cancer are more likely to develop severe illness (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines) (Singhal 2020) (Chittora et al. 2021) (Iyer et al. 2020). The first incidence of COVID-19 in India was reported

on January 30, 2020, in Kerala, and just four months later, the disease had spread to almost all Indian (Di Gennaro et al. 2020) (Abraham 2020). Day by day situation is going more critical and worst. It will generate a negative impact on the GDP of the country (Rio-chanona et al. 2020) (Wojcik 2020) (Mandel and Veetil 2020) (Rio-chanona et al. 2020) (Rose 2021). COVID-19 is evolving dynamically in Maharashtra as compared with the other states of India and which is ridiculous(Kachroo 2020). The virus puts a lot of burden on the health care system (Awan et al. 2021) (Tawonkasiwattanakun et al. 2021). There is no special treatment available currently to stop this spread (Yingzhu Li et al. 2021) (Kaur and Gupta 2020), but if everyone follows all the health-related guidelines as well as gets vaccinated as per government rules, the spread can be control (Ghosh, Ghosh, and Chakraborty 2020) (Sharma et al. 2021). In concern with the same, On 3rd January 2021, India's top drug regulator issued emergency approval for two vaccines (Covishield and Covaxin) before phase III clinical trials. Now, Covishield and Covaxin are still in use in India (Kumar et al. 2021). Covishield is a more well-known version of the Oxford University-AstraZeneca vaccine. Covishied is a chimpanzee adenovirus vector vaccine encoding the SARS-CoV-2 spike glycoprotein which is recombinant and replication-deficient. The Serum Institute of India develops Covishield, an Indian version. Covaxin, on the other hand, is India's first vaccine against COVID-19, developed by Bharat Biotech in collaboration with the Indian Council of Medical Research and the National Institute of Virology(Leeberk Raja Inbaraj, Carolin Elizabeth George 2021). Both vaccines works by priming the immune system with a SARS-CoV-2 spike protein and need two doses of 0.5 ml intramuscular injection with 4 to 6 weeks interval (Lefebvre et al. 2021) (Ranjit Sah et al.2021) (Shrestha et al. 2021). Covishield utilised a weakened adenovirus, whereas Covaxin used an inactivated SARS-CoV-2 virus extracted from an asymptomatic patient. Vaccines are biologics that offer disease-specific active adaptive immunity. The body produces new antibodies against distinct antigens as part of the immunity development process, which builds the defensive mechanism. When a person is infected repeatedly with the same antigen, the antibodies generated by the body either prevent or reduce the severity of the sickness caused by the antigen (Kashte et al. 2021). Chief of epidemiology and communicable diseases said, as both the vaccines emergency approved but the safety is not compromised with both the vaccines. Following a phase III clinical research, the Indian Council of Medical Research has declared that both vaccines are effective against mutant trains prevalent in India (Thiagarajan 2021).

Vaccination and its Importance

Vaccination is a simple, safe, and efficient approach to protect ourselves from illnesses that might damage us before they come in contact with us. It utilizes our defence system to build resistance to a specific infection, which helps to make our immune system stronger. Vaccines contain viruses or bacteria that are dead or weakened, and they do not affect the body. While they train our immune and defence systems to create antibodies to fight against harmful diseases. Vaccines are an important new weapon in the fight against COVID-19 (https://www.who.int/news-room/q-a-detail/vaccines-and-immunization-what-is-vaccination).

Review of Literature

Sami Ullah and et al., in their review, attempted to overview some important basic information about the pandemics like history, virological characteristics, structure, origin, and physiochemical properties. They also included the vaccination type and strategies in the second phase. which includes the

diagnosis, virology, and pathogenesis of SARS-CoV-2 and SARS-COV-2/COVID vaccines. The development, planning strategies, types, cost, and current scenarios of COVID-19 vaccines are also depicted in detail. They finally concluded in their review that the vaccination is an efficient and economical way to mitigate and control the epidemic but it requires mass production of successful COVID-19 vaccines (Ullah, Al-sehemi, and Saqib 2021).

In their review, Daniela Calina and et al. stated that immunization of the population by the vaccine is recognized as a public health priority in this triggered COVID-19 pandemic. They also concluded that social distancing is very expensive in terms of social and economic consequences. As a result, attempts to develop a successful COVID-19 vaccination programme will aid in the fight against COVID-19 (Calina et al. 2020).

Chia-Yu Chi and colleagues examined the progress of SARS-CoV-2 treatments and vaccines, focusing on current clinical studies and their challenges. They stated in their review that the vaccine candidates for SARS-CoV-2 are based on the viral spike protein, which plays a critical role in viral infection. They also advised that significant worldwide coordination and collaboration among studies, pharmaceutical firms, regulators, and governments is needed to prevent further damage due to the emerging SARS-CoV-2 virus (Shih et al. 2020).

Debjyoti Talukdar and et. al., according to their research, a broad range of information technology tools can play an important role in raising awareness of the COVID-19 immunization campaign. According to their survey of 60 nations across the world, 65.06 per cent of people are willing to get vaccinated, and many individuals believe the COVID-19 pandemic is a real threat to the community and preventive measures should be taken including the vaccination drives (Talukdar, Stojkovski, and Suarez 2021).

In their research of COVID-19, Ivan Franch-Pardo and colleagues highlighted some of the advantages of spatial analysis and GIS. COVID-19 research using GIS are mostly focused on decision-making. COVID-19 needs a multidisciplinary, global approach, with health geography providing a critical viewpoint that can help vulnerable populations. Data processed using GIS and spatial statistics are crucial to investigate COVID-19, according to their conclusions (Franch-pardo et al. 2020).

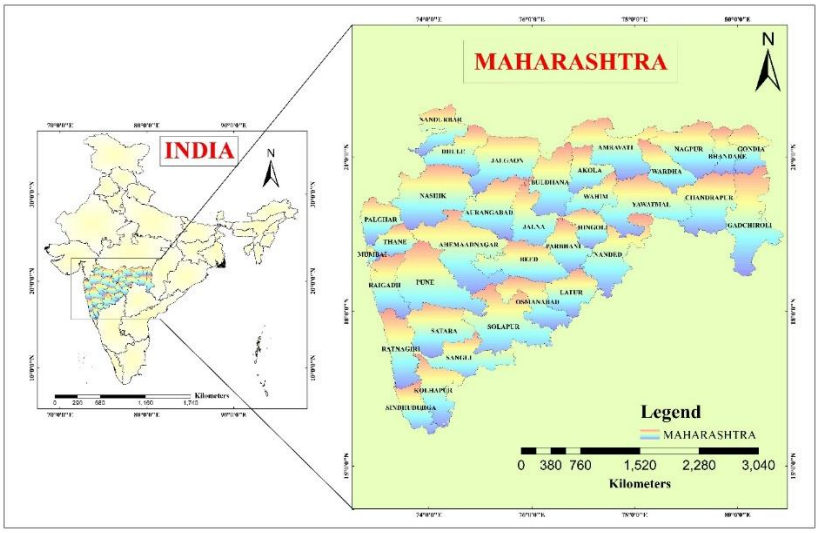

Figure 1. The Study Area (Maharashtra state of India)

Study Area

Maharashtra is one of the third-largest states of India if considered area-wise and it has 36 districts. The west side of Maharashtra is covered with the Arabian sea, while the north side is with the two states which are Gujarat and Madhya Pradesh. It is bordered on the south by Goa and Karnataka, and on the east by Telangana and Chhattisgarh. Figure 1 depicts the study area in the Maharashtra state of India. Mumbai is the capital of Maharashtra and is one of the most populous cities of India with a population of 13 million. Mumbai is also called the financial and commercial capital of India. Maharashtra was formed on May 1, 1960, when the bilingual Bombay State was divided. Marathi is the most common speaking language of Maharashtra. The state is one of India's most industrialized regions. Maharashtra is the single largest contributor to the national economy, contributing to 15% of the country's gross domestic product (Kodge 2021).

Table 1. District-wise COVID-19 Vaccination in the Maharashtra (https://dashboard.cowin.gov.in)

SR NO	DISTRICT	VACCINATION BY AGE			GENDERWISE			VACCINE CATEGORY			TOTAL VACCINATION DOSES		DISTRICTWISE VACCINATION
		18-44	45-60	ABOVE 60	MALE	FEMALE	OTHER	COVISHIELD	COVAXIN	SPUTNIK	DOSE 1	DOSE 2	
1	AHEMAADNAGAR	229868	361159	366346	526217	431069	87	782135	175238	0	741386	215987	957373
2	AKOLA	111296	161245	152357	229885	194959	54	350704	74194	0	335800	89098	424898
3	AMRAVATI	138755	245154	247989	338496	293331	71	493040	138853	5	484363	147530	631893
4	AURANGABAD	326979	307113	238578	500425	371974	271	817676	54994	0	706883	165787	872670
5	BEED	144159	186922	215280	300853	245428	80	473017	73344	0	437112	108216	545328
6	BHANDARE	108400	151961	160061	208971	211417	34	242514	177908	0	311012	109410	420422
7	BULDHANA	132136	220013	229489	311541	270008	89	461167	120471	0	455506	126132	581638
8	CHANDRAPUR	130205	200131	161985	264375	227896	50	455437	36884	0	402950	89371	492321
9	DHULE	139810	177111	144089	245379	215544	87	366481	94529	0	367005	94005	461010
10	GADCHIROLI	108051	100308	61239	144312	125251	35	229596	40002	0	225072	44526	269598
11	GONDIA	122518	215511	130377	230245	238107	54	288381	180025	0	377831	90575	468406
12	HINGOLI	76610	73292	67271	117143	99999	31	183713	33460	0	179638	37535	217173
13	JALGAON	202204	284889	274364	413056	348332	69	676463	84994	0	605024	156433	761457
14	JALNA	174748	151132	151584	257497	219908	59	395986	81478	0	397237	80227	477464
15	KOLHAPUR	179287	557498	597982	673796	660722	249	1243780	89503	1484	1046757	288010	1334767
16	LATUR	169561	186632	204422	305654	254892	69	468247	92368	0	448424	112191	560615
17	MUMBAI	2423226	1791475	1491166	3173271	2531686	910	5314202	389064	2601	4565564	1140303	5705867
18	NAGPUR	492744	642547	553174	903478	784704	283	1577380	110377	708	1330123	358341	1688464
19	NANDED	178613	231875	191748	325072	277089	75	461579	140657	0	475117	127119	602236
20	NANDURBAR	121756	189382	95425	214423	192103	37	362438	44125	0	345905	60658	406563
21	NASHIK	430177	534415	431091	778866	616647	170	1264926	130566	191	1119452	276231	1395683
22	OSMANABAD	97751	124099	140062	198550	163319	43	300361	61551	0	301635	60277	361912
23	PALGHAR	188173	211941	155152	302666	252548	52	521588	33678	0	457082	98184	555266
24	PARBHANI	128388	135744	134288	214465	183913	42	315754	82666	0	321950	76470	398420
25	PUNE	1911682	1495979	1292048	2586845	2112220	644	4314761	383514	1434	3757873	941836	4699709
26	RAIGADH	230209	254272	186076	388581	281900	76	608577	61980	0	561841	108714	670555
27	RATNAGIRI	111123	144808	126202	204911	177199	23	295011	87122	0	301560	80573	382133
28	SANGLI	167008	370191	365345	465091	437353	100	830925	71619	0	729487	173057	902544
29	SATARA	171487	389564	372025	489862	443130	84	832219	100857	0	763524	169552	933076
30	SINDHUDURGA	61029	103304	114179	141810	136665	37	211700	66812	0	221722	56790	278512
31	SOLAPUR	186175	289119	259676	408582	326306	82	711576	23394	0	587858	147112	734970
32	THANE	954664	923666	721682	1410014	1189479	519	2376995	222423	594	2101614	498398	2600012
33	WARDHA	96074	146011	146795	200480	188376	24	342077	46803	0	313851	75029	388880
34	WAHIM	86831	139990	124242	186843	164188	32	224394	126669	0	270203	80860	351063
35	YAWATMAL	150244	242801	183681	314945	261684	97	485007	91719	0	464540	112186	576726

Research Methodology

The Maharashtra state of India is particularly hard hit by COVID-19 infections. We have selected the Maharashtra state for our study to process and analyze the COVID-19 vaccination data because Maharashtra has the largest number of COVID-19 cases and is the most highlighted state in this COVID-19 pandemic. The main goal of this article is to gather data and then process, analyze, and visualize the graduated vaccination results for ease of understanding and future use. The COVID-19 vaccination primary data is collected from the Ministry of Health and Family Welfare (https://www.cowin.gov.in) and COVID-19 India (https://covid19india.org). After the collection of data, it is cleaned, processed, and organized in spreadsheets as needed. The collected COVID-19 vaccination data is processed for the required results. The special distribution map for the different parameters of the present study has been carried out using Arc GIS software.

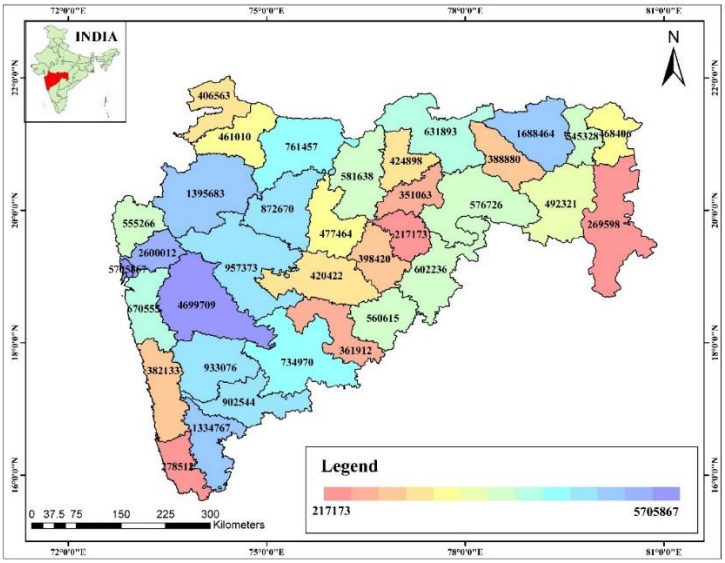

Figure 2. The status map of District-wise Vaccination Done in Maharashtra

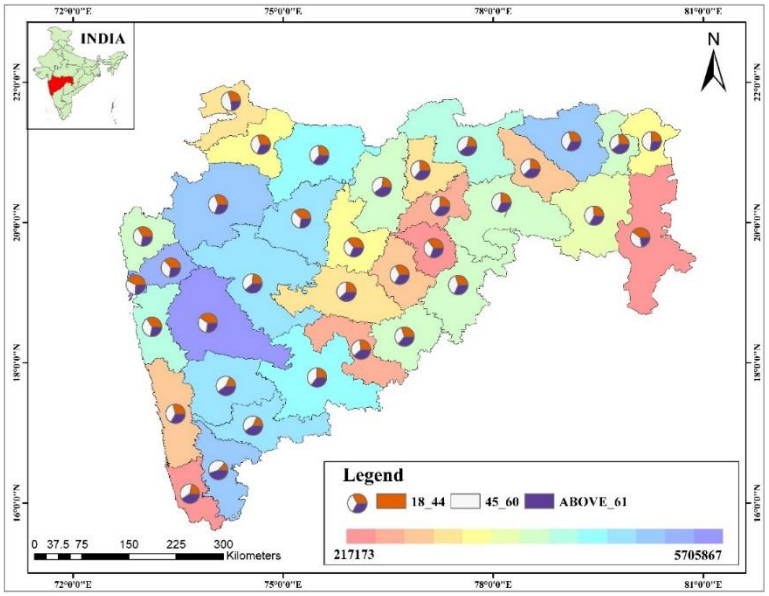

Figure 3. Pie diagram of COVID-19 Vaccination by Age in Maharashtra

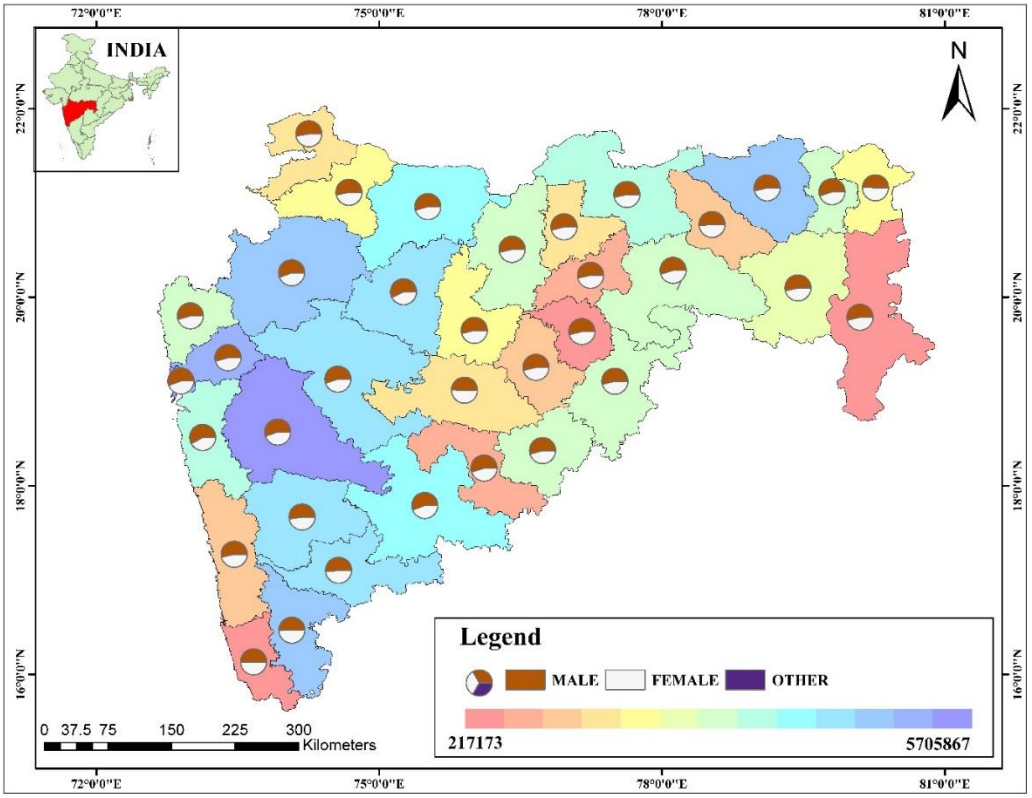

Figure 4. Pie diagram map of COVID-19 Vaccination by Gender in Maharashtra

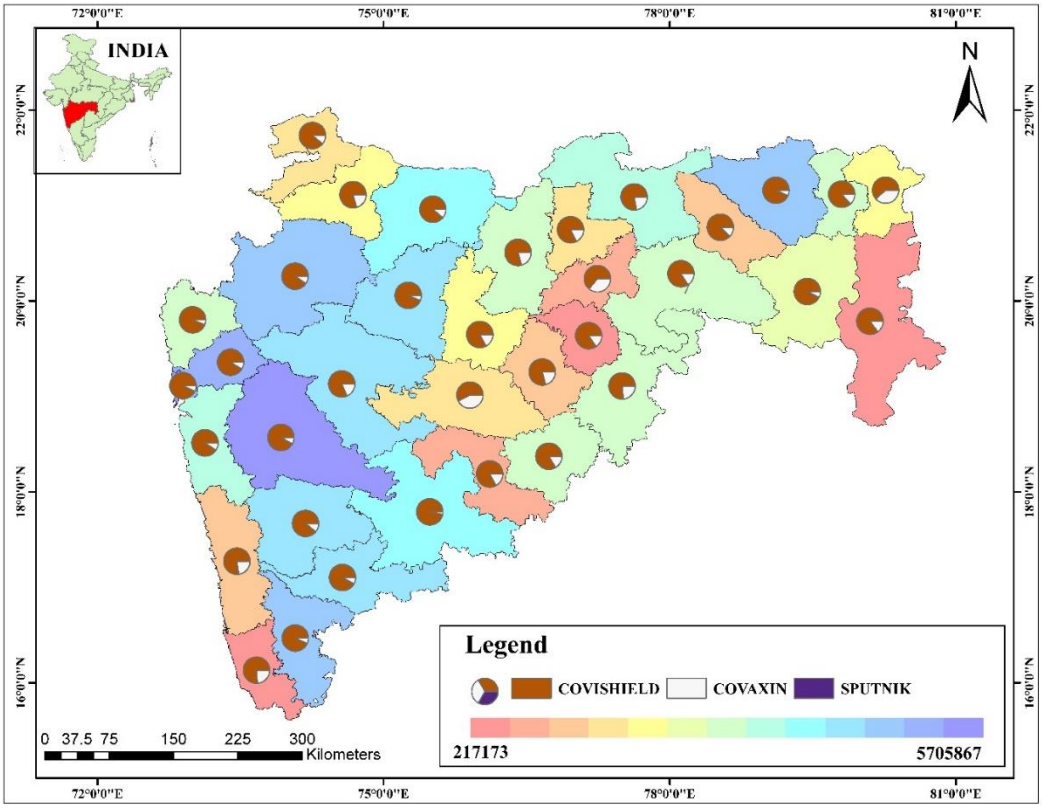

Figure 5. Pie diagram map of COVID-19 Vaccination by Vaccine Category in Maharashtra

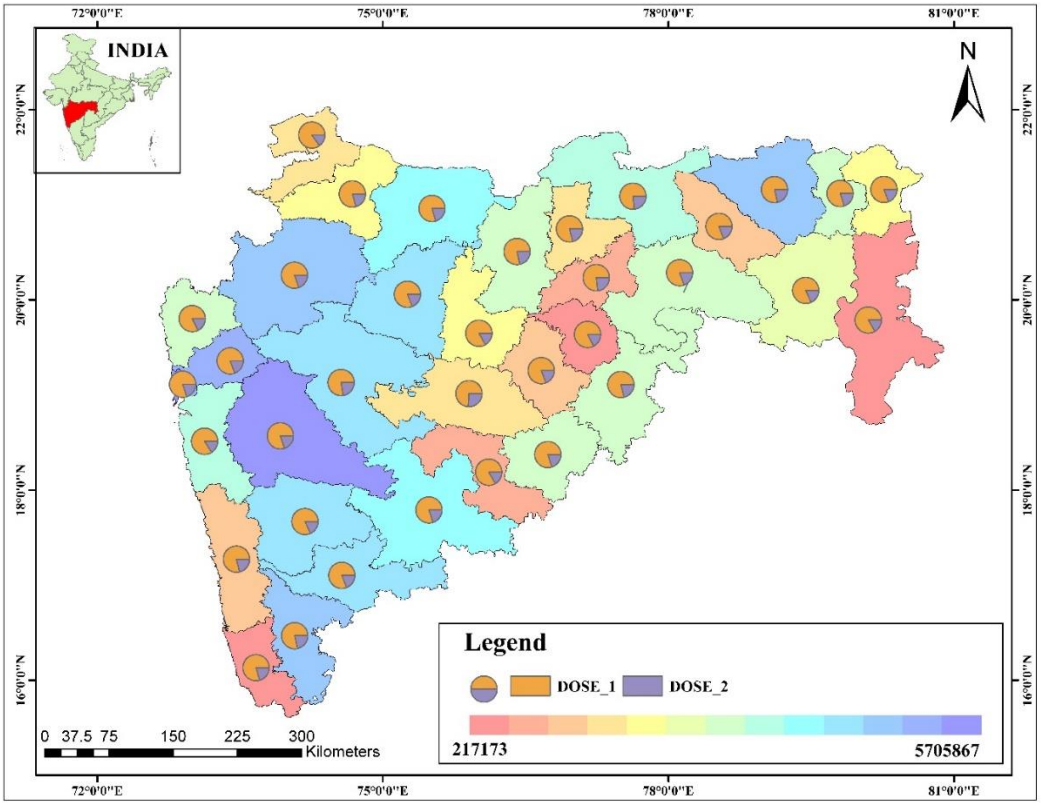

Figure 6. Pie diagram map of COVID-19 Vaccination by Dose in Maharashtra

Results and Discussions

After processing and combining vaccination and geospatial data, we compiled and generated district-wise graduated color maps of Maharashtra, which are depicted in Figures 1 to 6. The dark blue-colored districts in Figure 2 represent the states with the highest immunization rates, as well as their overall vaccination numbers. Maharashtra is the first state of India in which the highest vaccination is going on by different private and public health facilities. Mumbai, Pune and, Thane are the districts in Maharashtra where the highest vaccination is done. While, Hingoli, Gadchiroli, and Sindhudurga are the states where the COVID-19 vaccination is done at a very slow rate. Table 1 shows the district-wise, age-wise, gender-wise, vaccination category-wise, and dose-wise COVID-19 vaccination status in Maharashtra. We created a district-wise map based on the data in Table 1 to highlight Maharashtra's current vaccination status. The map of Figure 3 is generated to show the age-wise COVID-19 vaccination, the number of people of age 18-44, 45-60, and above 60 in each district using pie diagrams. Mumbai, Puna and, thane are the districts in which the highest vaccination of people above 60 years of age is done. While the Gadchiroli, Hingoli, and Nandurbar are the districts where the vaccination of above 60 age group peoples is very poor.

The map of Figure 4 is generated to show the gender-wise COVID-19 vaccination, the total number of males, females, and others in each district using the pie diagrams. Mumbai, Pune, and Thane are the districts in which the highest vaccination of males is done. While Hingoli, Sindhudurga, Gadchiroli and are the districts where the vaccination of males is very poor. In the case of females, Mumbai, Pune, and Thane are the districts in which the highest vaccination of females is done. While the Hingoli,

Gadchiroli, and Sindhudurga are the districts where the female responds very little to COVID-19 vaccination.

The Covishield and Covaxin are the two vaccines approved by India's top drug regulator in an emergency before phase III clinical trials. After that, Sputnik is launched in India. Now all three vaccines are in use in India as well as in Maharashtra. In Figure 5, again Mumbai, Pune, and Thane are the districts where the maximum Covishield vaccine is given. While Hingoli, Sindhudurga, and Washim are the districts where the Covishield is found less in number, maybe it's due to availability issues or the response of people to vaccination. In the case of Covaxine, Mumbai, Pune, and Thane are the districts where the maximum Covaxine doses are given. While Solapur, Hingoli, and Palghar are the districts in which the lesser Covaxine doses are given.

In Figure 6, it is shown that Mumbai, Pune, and Thane are the districts in which the maximum number of people have taken their first dose of vaccination. While Hingoli, Sindhudurga, and Gadchiroli are the districts where most of the people are still not taken their first dose. In the case of dose second, Mumbai, Pune, and Thane are again the districts where the people have taken their second dose as well. While Hingoli, Gadchiroli, and Sindhudurga are the districts in which very few people have taken their second dose.

Conclusion

In this paper, the information generated geographically is only showing the current status of COVID-19 vaccination in the Maharashtra state of India. The results shown in Figures 2 to 6 are the shreds of evidence showing the current status of the COVID-19 vaccination. The COVID-19 cases are increasing day by day in Maharashtra. The condition can be worst if the vaccination drive will not go properly. As per results, Mumbai, Puna, and Thane are the districts where the vaccination is going swiftly but the districts like Hingoli, Gadchiroli, Sindhudurga, and Washim found a slower rate of vaccination in Maharashtra. Might be it is an availability issue or lack of awareness in the public of the same districts where vaccination going at a very poor rate. Government has to focus on such districts and has to increase the awareness as well as the rate of vaccination to such districts. What goes the future of COVID-19 in Maharashtra is not known but it is sure if the vaccination in Maharashtra will not speed up, the third wave of COVID-19 is at our steps and then we have to live with COVID-19 for months to years. Hence, we should have to follow all the guidelines and protocols which are issued from time to time by the government regarding vaccination and social distancing to fight against COVID-19. We can prevent the death of ours and our dear ones and can prevent the coming cyclone if the botched vaccination campaign is rationalized and implemented with all due speed by the Maharashtra government. It is possible in two ways, first increasing vaccine supply and setting up a proper distribution campaign that can cover the rural and urban areas of Maharashtra. For that, the government has to work with the local and primary health care centers, because they know their communities. Also, the government has to create an equal distribution of vaccines before the vaccine is rolled out. Although safe and effective vaccines will be a game-changer, for the foreseeable future we should have to wear a mask and maintain physical distancing. According to the provisional results of the 2011 national census, the population of Maharashtra is 11,23,74,333. In such a huge populated state of India, only 2,65,12,901 vaccination is done. It means only 23.59% vaccination is done till July 2, 2021 in the Maharashtra state of India.

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