

COVID-19 Vaccine Hesitancy: What Have We Learnt? - A Cross-Sectional Survey Among Adults in Tamil Nadu, India

COVID-19 Aşı Tereddütü: Ne Öğrendik? - Hindistan, Tamil Nadu'daki Yetişkinler Arasında Kesitsel Bir Araştırma

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ABSTRACT

Aim: Today, vaccine hesitancy is one of the top 10 global health threats, which hinders adequate immunization coverage and herd immunity. The most recent global event that has led to a surge in vaccine hesitancy is the COVID-19 pandemic. COVID-19 vaccines have been studied extensively, but a sizable number of people continue to have misgivings towards COVID-19 vaccines.

Materials and Methods: We performed a cross-sectional survey among adults across Tamil Nadu, India, to measure the frequency of vaccine hesitancy and to understand the factors contributing to it.

Results: In our study population (n=1622), 49% were unwilling to get vaccinated. Hesitancy was higher among males when compared to females (54% vs. 41%) and among the older population when compared to the younger population (58% vs. 43%). The most preferred information sources regarding COVID-19 vaccines were television (38%), social media (25%), and newspapers (16%). Among the various social media platforms, WhatsApp was the most popular (33%), and Twitter was the least popular (2%). Half the population (52%) felt that herbal supplements were sufficient to provide immunity against COVID-19. The most common reason for hesitancy towards COVID-19 vaccination was the perception that the vaccine was not safe enough (52%).

Conclusion: Our study shows that even after sufficient time had passed since the start of the pandemic, vaccine hesitancy in a progressive state such as Tamil Nadu was disturbingly high. This warrants the need for more efforts to educate the public about the necessity of vaccines.

Keywords: COVID-19 vaccines, adults, willingness, source of information, hesitancy

ÖΖ

Amaç: Aşı tereddüdü, günümüzde yeterli aşılama ve sürü bağışıklığını engelleyen en önemli 10 küresel sağlık tehdidinden biridir. Aşı tereddüdünde artışa yol açan en son küresel olay COVID-19 salgınıdır. COVID-19 aşılarının kapsamlı bir şekilde incelenmesine rağmen, önemli sayıda insan COVID-19 aşılarına karşı şüphe duymaya devam etmektedir.

Gereç ve Yöntem: Aşı tereddüdünün sıklığını ölçmek ve buna katkıda bulunan faktörleri anlamak için Hindistan'ın Tamil Nadu kentindeki yetişkinler arasında kesitsel bir anket gerçekleştirdik.

Bulgular: Çalışma popülasyonumuzda (n=1622), %49'u aşı yaptırmak istemiyordu. Aşı yaptırmaya karşı isteksizlik, erkeklerde kadınlara kıyasla (%54'e karşı %41) ve yaşlı popülasyonda genç popülasyona kıyasla (%58'e karşı %43) daha yüksekti. COVID-19 aşıları hakkında en çok tercih edilen bilgi kaynakları televizyon (%38), sosyal medya (%25) ve gazetelerdi (%16). Çeşitli sosyal medya platformları arasında WhatsApp en popüler (%33) ve Twitter ise en az popüler olanıydı (%2). Nüfusun yarısı (%52), bitkisel takviyelerin COVID-19'a karşı bağışıklık sağlamak için yeterli olduğunu düşünüyordu. COVID-19 aşısına karşı tereddüdün en yaygın nedeni, aşının yeterince güvenli olmadığı algısıydı (%52).

Sonuç: Çalışmamız, pandeminin başlangıcından bu yana yeterli zaman geçmesine rağmen, Tamil Nadu gibi ilerici bir eyalette aşı tereddüdünün rahatsız edici derecede yüksek olduğunu gösteriyor. Bu durum, halkı aşıların gerekliliği konusunda eğitmek için daha fazla çaba gösterilmesinin gerektiğini ortaya koymaktadır.

Anahtar Kelimeler: COVID-19 aşıları, yetişkinler, isteklilik, bilgi kaynağı, tereddüt

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Received: 12.07.2024 Accepted: 12.09.2024

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INTRODUCTION

India has one of the largest immunization programs in the world, with a total coverage of 76.1% (National Family Health Survey 2019-2020)¹. The Universal Immunization Programme was implemented in the country in 1985. Under the aegis of the National Rural Health Mission, this program is a crucial, cost-effective public health intervention in the country. Immunization against 12 vaccine-preventable diseases is provided free of cost to the public, 11 at the national level (diphtheria, pertussis, tetanus, polio, measles, rubella, tuberculosis, hepatitis B, and meningitis or pneumonia caused by Haemophilus influenzae type b) and 3 at the sub-national level (rotavirus diarrhea, pneumococcal pneumonia, and Japanese encephalitis). These vaccines can be availed in any Indian state. The Government of India has also introduced strategies for capacity building and system strengthening through training programs, a National Cold Chain Management Information System, and an Electronic Vaccine Intelligence Network^{2,3}. However, there still remain factions that remain hesitant to take vaccines.

Vaccine hesitancy refers to a delay in acceptance or refusal of vaccination despite the availability of vaccination services. Vaccine hesitancy is complex and context specific, varying across time, place, and vaccines. It is influenced by factors such as complacency, convenience, and confidence. A Vaccine Hesitancy Determinants Matrix was developed by the Strategic Advisory Group of Experts on Immunization Working Group enumerating the various factors influencing vaccine hesitancy. These factors were divided into three categories – contextual influences, individual and group influences, and vaccine/ vaccination-specific issues⁴. This suggests the highly dynamic nature of vaccine hesitancy and the need for continuous research in this area.

Vaccine hesitancy is a phenomenon that has been reported ever since the discovery of the first vaccine⁵ by Edward Jenner in 1796. There are also reports of skepticism towards vaccines against other highly contagious infections such as diphtheria, pertussis, tetanus⁶, measles, mumps, rubella⁷, the Human Papilloma Virus⁸ and in recent times, COVID-19. Today, vaccine hesitancy is one of the top ten global health threats, as per the World Health Organization (WHO)⁹.

Vaccines became, unarguably, our most formidable weapon against the coronavirus pandemic that began in 2019. Regulatory authorities like the United States Food and Drug Administration, European Medicines Agency, Medicines and Healthcare products Regulatory Agency, and Central Drugs Standard Control Organization approved several vaccines against the SARS-CoV-2 virus, such as Pfizer-Biotech, Moderna, Sputnik, and Astrazeneca¹⁰. In India, the two most widely used vaccines were Covishield and Covaxin, developed by Serum Institute of India and bharat biotech, respectively^{11,12}. Since the beginning of vaccine rollout in mid-January 2021 until December 2021, approximately 1,32,93,84,230 doses were administered to the Indian public. The number rose to 2,20,67,82,117 in January 2024¹³. Overall, vaccine intake is steadily rising, but a sizable number of people remain hesitant to take vaccines.

Studies on COVID-19 vaccine acceptance and factors affecting it, performed in countries such as Ethiopia, Congo¹⁴, Portugal¹⁵, Ireland¹⁶, Japan¹⁷, UK¹⁸, and US¹⁹, have reported that vaccine hesitancy is a looming challenge today. Recent statistics show that 5% of the eligible population in India has received only a single dose, and 12% still remain unvaccinated against the coronavirus²⁰.

Tamil Nadu, a southern Indian state, has fared reasonably well with respect to social, economic, and health indicators in the last few decades. Yet a few studies report that COVID-19 vaccine hesitancy is a definite issue in this state, and it lags behind several others in COVID-19 vaccineuptake^{21,22}. The emergence of Omicron and its variants reiterate the importance of protection conferred by vaccines.

The effectiveness of a vaccine is heavily dependent on its rate of acceptance by the public. We aimed to study the magnitude of vaccine hesitancy across the state of Tamil Nadu, India, and factors influencing it. Since misinformation about COVID-19 disease and vaccines was rampant at the time, our study also assessed levels of trust in various information sources, including social media platforms. The results of this study can play a crucial role in combating vaccine hesitancy during public health vaccination campaigns in future pandemics.

MATERIALS AND METHODS

This cross-sectional study was performed among adults in Tamil Nadu, India, during August and September 2021. The study was performed in compliance with the ethical principles of the Declaration of Helsinki. The study was SRM Medical College Hospital and Research Centre initiated after getting approval from the Ethics Committee of our institution (decision no: 2871/IEC/2021, date: 23.01.2021) and registration in the Clinical Trial Registry of India. Based on the availability of manpower and resources, a systematic random sampling strategy was employed so that the survey covered rural, semi-urban, and urban households in all the regions of Tamil Nadu (north, south, west, and central). Considering the 2021 population of Tamil Nadu as 72,147,030 (https://censusindia.gov.in/census. website/data/data-visualizations/PopulationSearch PCA Indicators), 95% confidence level, and 3% margin of error, the minimum sample size required was calculated as 1.070. After a proper explanation of the study purpose and the acquisition of written informed consent from the participants, information

was collected using an author-designed, internally validated questionnaire. The questionnaire consisted of 7 sections with 41 guestions. Section 2 constituted the information sheet and informed consent, section 1 sought to determine sources of information used by the public, and section 3 assessed public perceptions regarding COVID-19 vaccines. Questions in sections 4, 5 and 6 were formulated in such a way so as to understand the degree of hesitancy and its contributing factors. Section 7 consisted of 8 questions that gathered demographic characteristics such as name, age, gender, educational status, occupation, and contact information (email/phone number, city, and district). The information was collected through a mixture of dichotomous and multiple-choice, close-ended guestions. Two guestions used the Likert-scale, and one openended guestion was added in section 6 to determine what was the most important information sought when a new vaccine is introduced or announced. Questions were prepared in English and Tamil languages. An online guestionnaire was used as an additional method to achieve a wider reach. The public was encouraged to participate in the survey by explaining about the study. No financial incentives were given to the participants.

Statistical Analysis

Data were analyzed using SPSS version 16.0. Continuous variables were expressed as mean \pm SD, and categorical variables were expressed as frequency with percentage. Comparison between various subgroups was done using the chi-square test. Multiple linear regression analyses were performed to determine the factors affecting vaccine hesitancy. A p-value less than 0.05 was considered statistically significant.

RESULTS

The baseline characteristics of the study population are described in Table 1. The mean age of participants was around 38 ± 15 years. 60% of the respondents were males. 57% had only completed school-level education, and 90% were not associated with the healthcare profession. The proportion of healthcare professionals among those with degrees was 22.3%.

The most preferred information source regarding COVID-19 vaccines was television (38%) followed by social media (25%). Among the various social media platforms, WhatsApp (33%), Facebook (20%), and Instagram (11%) were the most popular. YouTube (8%) and Twitter (2%) were the least popular. A fourth of the respondents (26%) reported that they did not trust social media for vaccine information.

The most preferred vaccines were Covishield (62%), and Covaxin (24%), and a majority believed that both vaccines were of equal safety and efficacy. 79% of participants preferred to take vaccines in injection form than any other means.

It was noted that almost half the respondents believed herbal supplements to be sufficient for immunity against COVID-19. A little more than half reported that vaccine-associated negative publicity caused them to lose interest in getting vaccinated. 58%were against compulsory vaccination for all.

When asked about the various concerns about the vaccines, fever was reported as the most common (24%) (Figure 1). 64% of participants reported that information regarding safety was most important when a new vaccine came to market (Figure 2). Although 95% of participants conveyed that no one within their social circles had developed serious adverse reactions to these vaccines and 62% believed that the vaccines were adequately monitored for safety by the government, it was surprising to note that almost half the population (49%) was unwilling to get vaccinated. 76% were not vaccinated even with a single dose. Multiple linear regression analyses were performed to obtain the odds ratio (OR) and to determine the factors affecting vaccine hesitancy (Table 2). Being a healthcare professional [OR: 3.354; 95% confidence interval (CI): 1.972-5.705; p<0.001], the presence of a vaccine mandate (OR: 4.164; 95% CI: 3.158-5.490; p<0.001), societal pressure to get vaccinated (OR: 2.058; 95% CI: 1.546-2.738; p<0.001), the belief that COVID-19 vaccines have been adequately studied (OR: 1.829; 95% CI: 1.394-2.400; p<0.001) and are being monitored for safety by the government (OR: 1.437; 95% CI: 1.093-1.889; p=0.01), endorsement of these vaccines by celebrities (OR: 1.637; 95% CI: 1.259-2.129; p<0.001), and ambiguity regarding the time interval required between vaccine doses (OR: 1.734; 95% CI: 1.286-2.339; p<0.001) were found to decrease vaccine hesitancy. On the other hand, negative publicity about vaccines (OR: 0.615; 95% CI: 0.476-0.794; p<0.001), the influence of anti-vaccination groups (OR: 0.734; 95% CI: 0.565-0.953; p<0.001), the presence of a major illness (OR: 0.400; 95% CI: 0.307-0.521; p<0.001), and a past history of COVID-19 infection (OR: 0.268; 95% CI: 0.202-0.356; p<0.001) were found to increase vaccine hesitancy.

Subgroup analyses were performed based on age (Table 3 (a)), gender (Table 3 (b)), and education level (Table 3 (c)). For obtaining vaccine information, older adults relied mostly on television, whereas youngsters had equal preferences for television and social media. WhatsApp and Facebook had a similar degree of preference in both age groups (34% vs. 32%, 21% vs. 18%, p=0.0001). Older adults had greater preference for herbal supplements (59% vs. 47%, p=0.0001). Youngsters were more in favor of compulsory vaccination (49% vs. 33%, p=0.0001) and they were also under greater societal pressure to get themselves vaccinated (39% vs. 33%, p=0.018). The proportion of the unvaccinated population was higher in the older age group (79% vs. 73%, p=0.01032).

Table 1. Baseline characteristics					
	Variable/characteristic	Frequency (%) or Mean <u>+</u> SD (n=1622)			
1.	Age (years)	37.88±15.38			
	Gender				
2.	Male	977 (60.2)			
	Female	645 (39.8)			
	Occupation - Health care professional				
3.	Yes	161 (9.9)			
	No	1461 (90.1)			
	Education				
Л	School level education	926 (57.1)			
т.	Completed undergraduate education	532 (32.8)			
	Completed postgraduate education	164 (10.1)			
	Sources used for information on COVID-19 vaccines				
	Television	631 (38.1)			
5	Social media	408 (25.2)			
5.	Newspaper/magazines	269 (16.6)			
	Healthcare professionals	242 (14.9)			
	Journal articles	72 (4.4)			
	Social media used for information on COVID-19 vaccines				
	WhatsApp	536 (33.0)			
	Do not trust social media	427 (26.3)			
6.	Facebook	319 (19.7)			
	Instagram	178 (11.0)			
	YouTube	132 (8.1)			
	Twitter	29 (1.8)			
	How was negative information related to COVID-19 vaccines clarified?				
	Ask a healthcare worker	629 (38.8)			
7.	Ask a friend/family/relative	572 (35.3)			
	Check authenticity on the internet	410 (25.3)			
	Others	11 (0.7)			
	Most trusted source for information on COVID-19 vaccines				
	Healthcare worker	907 (55.9)			
8.	Friend/family	524 (32.3)			
	Social media	168 (10.4)			
	Other	23 (1.4)			
	Least trusted source for information on COVID-19 vaccines				
_	Social media	871 (53.7)			
9.	Friend/family	573 (35.5)			
	Healthcare worker	164 (10.1)			
	Other	14 (0.9)			
10.	Do you trust the companies manufacturing COVID-19 vaccines?				
	Yes	1202 (74.1)			
	No	420 (25.9)			
11	Do you believe herbal supplements are sufficient for immunity against COVID-19 infection?				
11.	Yes	837 (51.6)			
	No	785 (48.4)			

Table 1. contiuned					
	Variable/characteristic	Frequency (%) or Mean ± SD (n=1622)			
	Do you believe COVID-19 vaccines strengthen the immune system?				
12.	Yes	1181 (72.8)			
	No	441 (27.2)			
	Most preferred COVID-19 vaccine				
	Covishield	1008 (62.1)			
	Covaxin	385 (23.7)			
13.	Sputnik	97 (6.0)			
	Pfizer	94 (5.8)			
	Moderna	20 (1.2)			
	Others	18 (1.1)			
	Attitude regarding Covishield and Covaxin				
	Covaxin and Covishield have equal safety and efficacy	973 (60.0)			
14.	Covishield is safer and more effective than Covaxin	387 (23.9)			
	Covaxin is safer and more effective than Covishield	214 (13.2)			
	Both Covishield and Covaxin are harmful	48 (3.0)			
	Preferred route of administration for COVID-19 vaccines				
	Injection	1284 (79.2)			
15.	Oral (tablet/svrup)	168 (10.4)			
	Nasal spray	151 (9.3)			
	Others	18 (1.1)			
	Does negative publicity influence your opinion about getting COVID-19 vaccines?				
16.	Yes	881 (54.3)			
	No	740 (45.6)			
	Do you believe that COVID-19 vaccination is a risk for your health?				
17.	Yes	550 (33.9)			
	No	1072 (66.1)			
	Do you think COVID-19 infection can occur even after vaccination?				
18.	Yes	319 (19.7)			
	No	1303 (80.3)			
	Should COVID-19 vaccine be made compulsory?				
19.	Yes	685 (42.2)			
	No	937 (57.8)			
	Do you feel social pressure to get COVID-19 vaccine?				
20.	Yes	588 (36.3)			
	No	1034 (63.7)			
	Are you concerned about side-effects of COVID-19 vaccines?				
21.	Yes	909 (56.0)			
	No	713 (44.0)			
	Serious adverse reactions to COVID-19 vaccines and percentage of participants who				
	knew at least one person in their circle that developed said reaction				
	No	1548 (95.4)			
	Death	30 (1.8)			
	Hospitalization	17 (1.0)			
22.	Fever with body pain	7 (0.4)			
	Body pain	6 (0.4)			
	Heart attack	5 (0.3)			
	Fever	4 (0.2)			
	Allergy	3 (0.2)			
	Headache	2 (0.1)			

	Variable/characteristic	Frequency (%) or Mean ± SD (n=1622)
23.	Do you believe that COVID-19 vaccines have been studied adequately? Yes No	1024 (63.1) 598 (36.9)
24.	Do you believe that COVID-19 vaccines are being adequately monitored for safety by the Government of India? Yes No	1000 (61.7) 622 (38.3)
25.	Do you believe that the vaccine should not be taken by persons with major illnesses such as cancer, heart disease, kidney disease etc.? Yes No	1081 (66.6) 541 (33.4)
26.	Are you willing to get vaccinated against COVID-19? Yes No Already vaccinated	663 (40.9) 796 (49.1) 163 (10.0)
27.	Have you been vaccinated against COVID-19? No Single Dose Double Dose	1225 (75.6) 278 (17.1) 118 (7.3)
28.	Do you believe that the vaccine is not needed if the person has a history of COVID-19 infection in the past? No, it is still required. Yes, it is not required.	1109 (68.4) 513 (31.6)
29.	Do you believe that celebrities can instill confidence in getting vaccinated against COVID-19 infection? Yes No	682 (42.0) 940 (58.0)
30.	Have you lost interest in getting the COVID-19 vaccine due to the time interval between the two doses? Yes No	418 (25.8) 1203 (74.2)

Older adults felt celebrities taking a COVID-19 vaccine made them more confident in doing the same when compared to younger adults (46% vs. 39%, p=0.009).

22% of males and 34% of females did not trust social media for information on vaccines (chi-square statistic 27.27; p=0.0001). There was no difference in preference towards social media platforms between genders. WhatsApp and Facebook were the most popular, and Twitter was the least popular information source. A greater proportion of male respondents reported that they felt greater social pressure to get vaccinated (52% vs. 39%, p=0.03) and that the vaccine should not be taken by persons with major illnesses (70% vs. 61%, p=0.0001). Most female respondents believed that vaccines ought to be made compulsory for all (51% vs. 36%, p=0.0001). They were also more willing to get vaccinated against COVID-19 (59% vs. 46%, p=0.0001). And as expected, a greater proportion of males were found to be unvaccinated compared to females (79% vs. 71%, p=0.0002).

When subgroup analysis was done with respect to education level, it was seen that television was the most preferred information source among school – educated participants (46%), whereas television and social media were equally preferred among college-educated participants (29% vs. 30%, p=0.0001). WhatsApp was the most popular social media platform in both groups. The school-level population preferred herbal supplements for immunity against COVID-19

infection (57% vs. 45%, p=0.0001) and was more influenced by negative publicity about vaccines (61% vs. 52%, p=0.0001). A greater proportion in the college educated group wanted the vaccine to be made compulsory (87% vs. 35% p=0.0001) and felt greater societal pressure to take vaccines (93% vs.

Concerns regarding COVID-19 vaccines 50 Percentage of participants (%) 45 40 35 30 25 20 15 10 5 0 No risk Fever Death Pain due to Allergy Others injection Cause of concern

Figure 1. Concerns regarding the vaccine

In our study, 56% of the population were concerned about the risk that might occur after being vaccinated. Fever (24%) and death (17%) were the most common concerns. Injection and allergy were the least common concerns 31%, p=0.0001). Unwillingness to get vaccinated was more prevalent among the school-completed population (58% vs. 38%, p=0.0001) and as expected, a greater proportion of these participants remained unvaccinated (82% vs. 67%, p=0.0001).





Safety (64%) was the most important information sought when the new vaccines came to market. This was followed by the efficacy (17%) of and information (10%) about the vaccine

Table 2. Factors affecting COVID-19 vaccine hesitancy						
Factor	Wald	Sig.	Exp (B)	95.0% CI for EXP (B)		
ractor				Lower	Upper	
Gender	1.647	0.199	0.847	0.657	1.092	
Occupation - healthcare professional	19.931	0.000	3.354	1.972	5.705	
Trust in vaccine manufacturing companies	2.562	0.109	1.281	0.946	1.734	
Negative publicity about vaccines	13.843	0.000	0.615	0.476	0.794	
Belief that vaccines are a risk to health	0.302	0.583	0.921	0.688	1.234	
Belief that vaccination will give you COVID-19 infection	0.040	0.842	0.967	0.693	1.348	
Vaccine mandate	102.155	0.000	4.164	3.158	5.490	
Societal pressure	24.503	0.000	2.058	1.546	2.738	
Influence of anti-vaccination groups	5.378	0.020	0.734	0.565	0.953	
Concern regarding the risks of the vaccine	0.694	0.405	1.117	0.861	1.450	
Belief that COVID-19 vaccines have been studied adequately	19.008	0.000	1.829	1.394	2.400	
Belief that COVID-19 vaccines are being adequately monitored for safety by the Government of India	6.726	0.010	1.437	1.093	1.889	
Need to get a booster dose	0.917	0.338	1.137	0.874	1.478	
Presence of a major illness	45.986	0.000	0.400	0.307	0.521	
History of COVID-19 infection in the past	83.088	0.000	0.268	0.202	0.356	
Vaccine endorsement by celebrities	13.525	0.000	1.637	1.259	2.129	
Ambiguity regarding time interval required between vaccine doses	13.007	0.000	1.734	1.286	2.339	
CI: Confidence interval						

Table 3 (a). Subgroup analysis – response of participants with respect to age				
	Variable/characteristic	n=1622	n=1622		
		Age <40	Age >40	p-value	
		n=967	n=655		
	Sources used for information on COVID-19 vaccines				
	Television	317 (32.8)	314 (47.9)		
	Social media	309 (31.9)	99 (15.1)		
1.	Newspaper/magazines	151 (15.6)	118 (18)	0.0001	
	Healthcare professionals	144 (14.9)	98 (14.9)		
	Journal articles	46 (4.8)	26 (3.9)		
	Social media used to acquire COVID-19 vaccine information.				
	WhatsApp	325 (33.6)	211 (32.2)		
	Facebook	202 (20.9)	117 (17.9)		
2.	Did not trust social media	201 (20.8)	228 (34.8)	0.0001	
	Instagram	165 (17)	12 (1.8)		
	YouTube	49 (5.1)	83 (12.7)		
	Twitter	25 (2.6)	4 (0.6)		
	How was negative information related to COVID-19 vaccines clarified?				
	Ask a healthcare worker	343 (35.5)	286 (43.7)		
3.	Check authenticity on the internet	309 (31.9)	101 (15.4)	0.0001	
	Ask a friend/family/relative	308 (31.9)	264 (40.3)	0.0001	
	Others	7 (0.7)	4 (0.6)		
	Most trusted source for information on COVID-19 vaccines				
	Healthcare worker	574 (59.4)	333 (50.8)		
4.	Friend/family	256 (26.5)	268 (40.9)	0.0001	
	Social media	123 (12.7)	45 (6.9)		
	Other	14 (1.4)	9 (1.4)		
	Least trusted source for information on COVID-19 vaccines				
	Social media	487 (50.4)	384 (58.6)		
5.	Friend/family	365 (37.7)	208 (31.8)	0.011	
	Healthcare worker	107 (11)	57 (8.7)		
	Other	8 (8.3)	6 (0.9)		
	Do you believe herbal supplements are sufficient for immunity against COVID-19 infection?				
6.	Yes	454 (46.9)	383 (58.5)	0.0001	
	No	513 (53)	272 (41.5)		
	Most preferred COVID-19 vaccine				
	Covishield	550 (56.9)	458 (69.9)		
	Covaxin	244 (25.2)	141 (21.5)		
7.	Sputnik	80 (8.3)	17 (2.6)	0.0001	
	Pfizer	64 (6.6)	30 (4.6)		
	Moderna	16 (1.7)	4 (0.6)		
	Other	13 (1.3)	5 (0.8)		
	Attitude regarding Covishield and Covaxin:				
	Covaxin and Covishield have equal safety and efficacy	529 (54.7)	444 (67.7)		
8.	Covishield is safer and more effective than Covaxin	254 (26.3)	133 (20.3)	0.0001	
	Covaxin is safer and more effective than Covishield	153 (15.8)	61 (9.3)		
	Both Covishield and Covaxin are harmful	31 (3.2)	17 (2.6)		
	Should COVID-19 vaccine be made compulsory?				
9.	Yes	469 (48.5)	216 (32.9)	0.0001	
	No	498 (51.5)	439 (67)		

Table 3 (a). continued					
		n=1622			
	Variable/characteristic	Age <40	Age >40	p-value	
		n=967	n=655		
	Do you feel social pressure to get COVID-19 vaccine?				
10.	Yes	373 (38.6)	215 (32.8)	0.019	
	No	594 (61.4)	440 (67.2)	0.018	
	Do you believe that COVID-19 vaccination is a risk for your health?				
11.	Yes	582 (60.2)	327 (49.9)		
	No	385 (39.8)	328 (50)	0.0001	
	Are you willing to get vaccinated against COVID-19?				
12.	Yes	553 (57)	273 (42)	0.0001	
	No	414 (42.8)	382 (58.3)		
	Have you been vaccinated against COVID-19?				
13.	Yes	258 (27)	138 (21)	0.01032	
	No	709 (73.3)	516 (78.8)		
	Do you believe that the vaccine is not needed if the person has a history of COVID-19 infection in the past?				
14.	No, it is still required.	697 (72)	412 (62.9)	0.0001	
	Yes, it is not required.	270 (27.9)	243 (37)		
15.	Do you believe that celebrities can instill confidence in getting vaccinated against COVID-19 infection?				
	Yes	381 (39.4)	301(45.9)	0.009	
	No	586 (60.5)	354 (54)		

DISCUSSION

Our study shows that 49% of study participants were unwilling to take vaccines. This finding resonates with an earlier study carried out across rural and urban groups in Tamil Nadu where 40.7% of participants were vaccine hesitant and 19.5% were vaccine deniers²¹. Similarly, a 2019-2020 study done in Maharashtra, India, showed that 37% of participants were either unwilling or unsure about receiving vaccines. Although WHO and Center for Disease Control (CDC) have declared that COVID-19 is no longer a public health emergency^{23,24}, herd immunity granted by vaccines still remains a formidable weapon against the disease at the community level, particularly in the face of new viral variants. Hence, it is essential that vaccine hesitancy be tackled effectively. At the time of data collection, more than ten months had passed since vaccine rollout, but the fact that half the study population was still unwilling to get vaccinated remains intriguing. One would expect that a greater degree of acceptance would have set in due to increasing knowledge gained about these vaccines.

Our study examined the various factors influencing vaccine hesitancy. Positive factors that reduced vaccine hesitancy included being a healthcare professional, the presence of a vaccine mandate, societal pressure to get vaccinated, the belief

that COVID-19 vaccines have been adequately studied and are being monitored for safety by the government, endorsement of vaccines by celebrities, and ambiguity regarding the time interval required between vaccine doses. The higher acceptance of vaccines among healthcare professionals may be explained by their knowledge about the mechanisms underlying vaccination and its benefits, clinical experience, and the risk they face as frontline workers, especially during pandemics²⁵.On the other hand, they may also be reluctant to voice their hesitancy towards vaccines due to pressures from various organizations and their position as role models to the public. The introduction of a vaccine mandate appears to reduce vaccine hesitancy, possibly due to the fact that it is an authoritative decree that could impact several social activities, such as admission to schools and workplaces. It appears that the public perceives a vaccine mandate as a punitive strategy because 58% of our study population were against compulsory vaccination. They feel coercion is unwarranted as it forces them to take vaccines even when they are not personally convinced of their safety and efficacy. However, this is not the first instance of coercion for vaccination. For example, in the USA, children are expected to get vaccinated before attending school. Similarly, in Italy, fines are imposed if children do not take their regular vaccinations²⁶. The third factor that appears to reduce vaccine hesitancy is societal pressure.

During the subgroup analysis, it was observed that unwillingness was more pronounced among males (54% vs. 41%; p<0.0001), probably due to greater social pressure from their employers to get vaccinated. However, few Indian studies report greater vaccine hesitancy among females²². 42% of our participants agreed that endorsement from notable personalities could be a favorable factor in influencing public opinion. The regression analysis also arrived at the same conclusion. The trust that COVID-19 vaccines have been adequately studied and are being monitored for safety by the government were other factors that reduced vaccine hesitancy. 38% of our study population felt that COVID-19 vaccines were inadequately studied. A similar proportion believed the Indian Government had not sufficiently evaluated vaccine safety.

Table 3 (b). Subgroup analysis – response of participants with respect to gender			
		n=1622		
	Variable/characteristic	Male	Female	p-value
		n=977	n=645	
	Social media used for information on COVID-19 vaccines			
	WhatsApp	348 (35.6)	188 (29.1)	
	Facebook	226 (23.1)	93 (14.4)	
1.	Do not trust social media	213 (21.8)	216 (33.5)	0.0001
	Instagram	93 (9.5)	84 (13.0)	
	YouTube	77 (7.9)	55 (8.5)	
	Twitter	20 (2)	9 (1.4)	
	Preferred route of administration for COVID-19 vaccines			
	Injection	777 (79.5)	507 (78.6)	
2.	Nasal spray	103 (10.5)	48 (7.4)	0.026
	Oral (tablet/syrup)	87 (8.9)	81 (125)	
	Others	10 (1)	8 (1.2)	
	Does negative publicity influence your opinion about getting COVID-19			
3	vaccines?	565 (57.8)	312 (48 3)	0.0001
0.	Yes	412 (42 1)	332 (51.4)	0.0001
	No	+12 (+2.1)	332 (31.4)	
	Should COVID-19 vaccine be made compulsory?			
4.	Yes	355 (36.3)	330 (51.1)	0.0001
	No	622 (63.6)	315 (48.8)	0.0001
	Do you feel social pressure to get COVID-19 vaccine?			
5.	Yes	334 (51.8)	254 (39.4)	0.033
	No	643 (65.8)	391 (60.6)	
	Are you concerned about side effects of COVID-19 vaccines?			
6.	Yes	502 (51.4)	407 (63.1)	0.0001
	No	475 (48.6)	238 (36.9)	
	Do you believe that the vaccine should not be taken by persons with major			
7.				0.0001
	Tes No.	687 (70.3)	394 (61.4)	
		290 (29.7)	251 (38.9)	
	Are you willing to get vaccinated against COVID-19?			
8.	Yes	446 (46)	380 (59)	0.0001
	No	531 (54.3)	265 (41)	
	Have you been vaccinated against COVID-19?			
9.	Yes	207 (21)	189 (29)	0.0002
	No	769 (78.7)	456 (70.7)	
	Do you believe that the vaccine is not needed if the person has a history of COVID-19 infection in the past?			
10.	No, it is still required.	636 (65)	473 (73.3)	0.0001
	Yes, is it not required.	341 (34.9)	172 (26.7)	

Table 3 (c). Subgroup analysis - Response of participants with respect to education level					
		n=1622			
	Variable/characteristic	School level	College level	p-value	
		n=926	n=696		
	Sources used for information on COVID-19 vaccines				
	Television	429 (46.3)	202 (29.0)		
	Social media	200 (21.6)	208 (29.9)		
1.	Newspaper/magazines	148 (15.9)	94 (13.5)	0.0001	
	Healthcare professionals	129 (13.9)	140 (20.1)		
	Journal articles	20 (2.2)	52 (7.5)		
	Social media used for information on COVID-19 vaccines				
	WhatsApp	291 (31.4)	245 (35.2)		
	Do not trust social media	272 (29.4)	157 (22.5)		
2.	Facebook	181 (19.5)	138 (19.8)	0.0001	
	YouTube	98 (10.6)	34 (4.8)		
	Instagram	76 (8.2)	101 (14.5)		
	Twitter	8 (0.9)	21 (3.0)		
	How was negative information related to COVID-19 vaccines clarified?				
	Ask a friend/family/relative	363 (39.2)	209 (30.0)		
3.	Ask a healthcare worker	352 (38.0)	277 (39.8)	0.0001	
	Check its authenticity in the internet	206 (22.2)	204 (29.3)		
	Others	5 (0.5)	6 (0.8)		
	Do you trust the companies manufacturing COVID-19 vaccines?				
4.	Yes	712 (76.8)	490 (70.4)	0.003	
	No	214 (23.1)	206 (29.5)		
	Do you believe herbal supplements are sufficient for immunity against COVID-19 infection?				
5.	Yes	525 (56.7)	312 (44.8)	0.0001	
	No	401 (43.3)	384 (55.1)		
	Do you believe COVID-19 vaccines strengthen the immune system?				
6.	Yes	698 (75.4)	483 (69.3)	0.007	
	No	228 (24.6)	213 (30.6)		
	Attitude regarding Covishield and Covaxin				
	Covaxin and Covishield have equal safety and efficacy	618 (66.7)	355 (51.0)		
7.	Covishield is safer and more effective than Covaxin	193 (20.8)	194 (27.9)	0.0001	
	Covaxin is safer and more effective than Covishield	100 (10.8)	114 (20.7)		
	Both Covishield and Covaxin are equally harmful	15 (1.6)	33 (4.7)		
0	Does negative publicity influence your opinion about getting COVID-19 vaccines?			0.0001	
8.	Yes	566 (61.1)	360 (51.7)	0.0001	
	No	360 (38.9)	384 (55.1)		
	Do you believe COVID-19 infection can occur even after vaccination?				
9.	Yes	148 (15.9)	171 (24.5)	0.0001	
	No	778 (84.0)	525 (75.0)		
	Should COVID-19 vaccine be made compulsory?				
10.	Yes	323 (34.9)	603 (86.6)	0.0001	
	No	603 (65.1)	334 (48.0)		
	Do you feel social pressure to get COVID-19 vaccine?				
11.	Yes	282 (30.5)	644 (92.5)	0.0001	
	No	644 (69.5)	390 (56.0)		

Table 3 (c). continued					
		n=1622			
	Variable/characteristic	School level	College level	p-value	
		n=926	n=696		
	Are you concerned about side effects of COVID-19 vaccines?				
12.	Yes	474 (51.2)	452 (65.0)	0.0001	
	No	452 (48.8)	261 (37.5)	0.0001	
	Do you believe COVID-19 vaccines have been studied adequately?				
13.	Yes	613 (66.2)	313 (45.0)	0.003	
	No	313 (33.8)	285 (41.0)		
	Do you believe that the vaccine should not be taken by persons with major illnesses such as cancer, heart disease, kidney disease etc.?			0.045	
14.	Yes	636 (68.7)	445 (64.0)	0.045	
	No	290 (31.3)	251 (36.1)		
	Are you willing to be vaccinated against COVID-19?				
15.	Yes	393 (42.0)	433 (62.0)	0.0001	
	No	533 (57.6)	263 (37.8)	0.0001	
	Have you been vaccinated against COVID-19?				
16.	Yes	162 (17.0)	232 (33.0)	0.0001	
	No	761 (82.2)	464 (66.6)	0.0001	
47	Do you believe that the vaccine is not needed if the person has a history of COVID-19 infection in the past?				
17.	No, it is still required.	609 (65.8)	500 (72.0)	0.009	
	Yes, it is not required.	317 (34.2)	196 (28.1)		
18.	Do you believe that celebrities can instill confidence in getting vaccinated against COVID-19 infection?				
	Yes	410 (44.2)	272 (49.1)	0.036	
	No	516 (55.7)	424 (61)		
19.	Do you think that people may lose interest in getting COVID-19 vaccine because of the time interval between the two doses?				
	Yes	199 (21.5)	219 (31.4)	0.0001	
	No	726 (78.4)	477 (68.5)		

Some opined that more transparency was needed in sharing vaccine related information to the public. Although clinical trial results are available in the public domain, data from these trials are limited compared to the large vaccine roll-out database that the Indian Government has with respect to vaccine safety among recipients. Periodical disclosure of safety issues may elicit a greater degree of trust from the public. However, the authors are of the opinion that availability of more information could sometimes be counterproductive, if interpreted inappropriately.

Two of the factors that increased public vaccine hesitancy were negative publicity regarding vaccines and the influence of anti-vaccination groups. The presence of a major illness also made people hesitant to get vaccinated. Subgroup analysis revealed that older adults were more hesitant to get vaccinated, possibly due to greater fear with respect to safety issues and the presence of comorbidities. The majority of the participants also felt that taking vaccines in the presence of major illnesses such as cancer, heart or kidney disease was inappropriate, a perception shared among the various subgroups. An Indian survey among cancer patients revealed that 60% were vaccine hesitant, mainly for fear of the vaccine impacting cancer therapy, its side-effects, and lack of information²⁷. These findings are consistent with studies done in the USA and other low- and middle-income countries²⁸. A history of COVID-19 infection in the past was also a factor that contributed to increased vaccine hesitancy. Despite the government announcing that the vaccine can be taken 3 months after recovery from infection, 32% of the study population believed it was unnecessary for people who had a past history of COVID-19. This perception may have arisen from the knowledge that viral infections such as chickenpox and measles confer lifelong immunity to those infected once. However, experience has shown that naturally acquired immunity to COVID-19 is short-lasting and several thousand individuals were infected during both the first and second waves²⁹. The CDC states that vaccination can be delayed up to 3 post-infection months, but beyond that, booster doses with updated vaccines must be taken pr omptly²⁴. This becomes crucial as the coronavirus continues to mutate and new variants emerge. This fact does not seem to have registered in people's minds, hence indicating the importance of communicating the need for vaccination even in those with a history of infection. Hesitancy was also higher among those with lesser education, a trend reported even in European and Canadian studies^{30,31}. The major reasons for vaccine hesitancy among our participants were safety and availability (Figure 3).

Safety has been cited as a major concern even in earlier reports³². This is despite the fact that the prevalence of serious adverse events due to COVID-19 vaccines is extremely low. This could be attributed to fear mongering tactics by peddlers of misinformation who circulate fallacies and raise doubts about the vaccines' safety. In addition, it is a natural tendency for the human mind to succumb to 'negativity bias', i.e., it tends to remember the rare event of a serious adverse reaction occurring in one individual rather than the daily mundane news of millions taking the vaccine without any adverse reaction. Although the government undertook the herculean task of vaccinating the Indian population at a rapid pace, myths regarding vaccine safety still prevail. The CoWin platform, launched by the Indian government, was a welcome step that helped instill public faith in the government. This platform served as a digital backbone during the pandemic, helped increase transparency, and added credibility to the vaccination process. Collaborations between healthcare



Figure 3. Most common reasons for vaccine hesitancy

The major reason for not getting vaccination was safety concerns (52%), followed by availability (20%) and efficacy (12%). Cost (5%) and reduced case load of COVID-19 (4%) were other reasons for not getting the vaccine

workers, activists, celebrities, and governmental and nongovernmental organizations play key roles in this aspect.

In our study, television was the most preferred source of information about vaccines (38%). This pattern was more common among the elderly and in those with school-level education. This trend was also observed in a survey carried out in Israel, where the majority of respondents reported getting COVID-19 vaccine information from local television³³. The next important source of information was social media (25%). among which WhatsApp (33%) and Facebook (18%) were used by the majority. As anticipated, youngsters tended to use social media more when compared to the elderly (63% vs. 15%. p=0.0001). Similar results were seen in a health information national trends survey (2013, 2014, & 2017) in the USA, which reported significantly higher odds of the younger generation using social media for health communication³⁴. Although social media provides abundant information, respondents in our study have agreed that its authenticity remains guestionable, and hence it was the least trusted source (54%). Likewise, a cross-sectional study in Saudi Arabia showed that the majority of the participants did not trust information from social media, with WhatsApp being their least trusted source³⁵. Participants placed reasonable trust in information obtained from healthcare workers (56%), but they reported that this was not easily accessible³⁶. Scholarly articles that had the most precise and authentic information about vaccines were the least commonly used sources. Thus, it is imperative that accurate information regarding vaccines is disseminated aggressively by healthcare authorities through non-traditional methods like social media and television. Public engagement by the healthcare community through television may help address double-minded fence-sitters.

More than half the study participants (52%) believed that traditional herbal supplements like Kabasura Kudineer were sufficient for immunity against COVID-19. Although studies have shown that this formulation has beneficial effects in improving viral clearance³⁷⁻³⁹, there are no studies to back its ability to prevent infection. Yet a good number of people do trust in its ability to prevent infection, thereby perpetrating a false sense of assurance.

Lessons learnt from COVID-19 vaccination may be extrapolated and used to tailor tactics that can improve vaccine acceptance rates during future pandemics. Efforts must be made early during the vaccine development period to understand the factors contributing to hesitancy. Infodemics are prevalent during any global crises, and the role played by the media is crucial during those times. As shown in our study, there is high information uptake from unreliable sources, making it imperative to ensure that data from infodemics are carefully filtered.

Study Limitations

Firstly, although the study attempted to gauge perception and behavioral practices towards COVID-19 vaccination among adults across Tamil Nadu, certain regions of the state were relatively underrepresented. However, care was taken to ensure that urban, semi-urban, and rural populations were included in the study. Secondly, the survey was done online for one-third of participants. Hence, the possibility of them not comprehending the questions cannot be ruled out. Thirdly, since vaccine hesitancy ebbs and flows as time progresses and more information becomes available, a follow-up study would have proven beneficial. But this was not included in the protocol for our study.

CONCLUSION

Age, gender, education level, and social media play major roles in formulating beliefs and thus determining the degree of public hesitancy toward vaccines. Our study showed that even after a year of the pandemic, vaccine hesitancy in a progressive state such as Tamil Nadu, India, was disturbingly high. This warrants increasing efforts to educate the public on the effectiveness and safety of vaccines. Greater engagement of healthcare workers through social media on the beneficial effects of vaccination is pivotal. Adequate measures must be ensured to convey accurate information and to increase public vaccine literacy through reliable sources.

Ethics

Ethics Committee Approval: The study was SRM Medical College Hospital and Research Centre initiated after getting approval from the Ethics Committee of our institution (approval number:2871/IEC/2021, date: 23.01.2021) and registration in the Clinical Trial Registry of India (CTRI/2021/08/035885).

Informed Consent: After a proper explanation of the study purpose and the acquisition of written informed consent from the participants, information was collected using an author-designed, internally validated questionnaire.

Footnotes

Authorship Contributions

Concept: M.G., Design: M.G., Data Collection or Processing: I.P., C.S.C., B.G.R., A.K.M., N.K.D., V.P.J.S., Analysis or Interpretation: M.G., K.M., I.P., V.P.J.S., Literature Search: K.M., J.J., C.S.C., Writing: M.G., K.M., J.J., C.S.C.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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