Perceptions of COVID-19 Spread Factors, Socio-Demographic Influences, and Vaccine Efficacy: Insights from Frontline Health Workers in Bhopal, India

Anita Sahu* and Jagdish Prasad

Department of Statistics, School of Applied Sciences, Amity University, Jaipur, Rajasthan 303002, India

Abstract: *Background*: As frontline warriors against COVID-19, health workers have gained a significant, unique, and invaluable understanding of the virus through personal experience and various studies over the past five years. These insights can provide a more precise understanding of the factors influencing the spread of COVID-19, as well as socio-demographic factors and vaccine efficacy in the long term. Despite a growing body of pandemic literature, studies that capture healthcare workers' perceptions of community-level transmission remain scarce, and even fewer examine those perceptions alongside socio-demographic drivers and vaccine performance.

Objective: To understand what healthcare workers, think about COVID-19 spread factors, socio-demographic influences, and vaccine efficacy in the community, and to assess the key factors they identify, along with the differences and similarities in their perceptions across professional groups.

Materials and Methods: A structured questionnaire comprising 32 questions was administered to 252 health workers in Bhopal, India, including doctors, nurses, laboratory technicians, pharmacists, and ambulance drivers. In this study, a descriptive and comparative analysis is performed to identify factors contributing to the spread of COVID-19, as well as significant differences and similarities in how various professions classified and identified these factors, and the demographic risks associated with them. The analysis also evaluates the long-term effectiveness of vaccines. Data were analyzed using the Borda Count technique to establish rankings, while Kendall's W was used to quantify the strength of agreement across different medical roles.

Results: The study revealed notable variations in how different healthcare professions perceived factors influencing the spread of COVID-19, socio-demographic influences, and vaccine efficacy. Doctors and nurses displayed the closest alignment, while pharmacists, lab technicians, and ambulance drivers offered distinct viewpoints shaped by their roles and exposure levels. Despite these differences, all groups agreed on the major transmission mechanisms, the effectiveness of preventive measures, and the importance of vaccination in reducing severity.

Conclusion: Health workers across professions contributed diverse but meaningful perspectives on COVID-19, reflecting their clinical and operational experiences. While some differences emerged, there was shared recognition of the need for public cooperation, early detection, and sustained vaccination efforts. These insights underscore the importance of a multidisciplinary, locally responsive approach to enhancing pandemic preparedness and future public health strategies.

Keywords: COVID-19, Frontline health workers, Socio-demographic factors, Vaccine effectiveness, Perception study, India.

INTRODUCTION

Coronavirus is one of the most devasting viruses and was responsible for a global pandemic. It was first reported in December 2019 in Wuhan, China and spread globally. All over the world, a total of 777 million people were affected, and over 7.1 million deaths were reported by February 22nd, 2025 [1]. India reported its first COVID-19 cases on January 30th, 2020, in Kerala and subsequently spread over other states of India [2]. So far, a total of 45 million cases and 534K deaths have been reported in India [1]. India mainly phases the three waves: the first in 2020, the second in March 2021 and the post-vaccination in January 2022. All the waves differed in severity, infectivity, symptoms, transmission pattern, and challenges [3-5]. India executed the biggest vaccination campaign in history [1, 6]. The vaccine drive was a challenge in the early stage, and people have shown hesitancy towards the vaccine despite the enormous effect of the government. Vaccine hesitancy was not the only challenge in India; the whole world faced this challenge. WHO marked it as one of the most critical challenges ever [7, 8]. However, in the late stage, people started accepting the vaccine due to the government's awareness campaign. As a result, as of February 22nd, 2025, a total of 2.21 billion people have been vaccinated so far [9].

Madhya Pradesh is situated in the centre of India, with Bhopal being the capital city. It is India's second-largest land area state and its fifth-largest state in population. More than 75% of MP's population resides in rural areas [10]. Madhya Pradesh reported its first COVID-19 case on March 20, 2020 [11]. Around 1 million cases and 10787 deaths were reported in MP as of February 22nd, 2025 [9]. The disease presentation was changed during the waves. For instance, in Madhya Pradesh, during the first wave, the percent positivity amongst males was higher in comparison to females, whereas during the second wave, the percent positivity amongst females was more than in males [12]. In India, during the first wave, the positive rate was lower, but the death rate was higher where, whereas in the second wave, the positive rate was higher, but the death rate was lower [13, 14].

*Address correspondence to this author at the Department of Statistics, School of Applied Sciences, Amity University, Jaipur, Rajasthan 303002, India;
E-mail: sahu01anita@gmail.com

Understanding the heterogeneity of COVID-19 can help us to prepare for future pandemics. Healthcare workers were the first responders when COVID-19 struck, moving seamlessly from contact-tracing to testing, from preventive counselling to bedside care. Whether doctors, nurses, pharmacists, laboratory technicians, or even ambulance drivers, their continuous, hands-on engagement throughout every phase of the pandemic gives them a uniquely panoramic view of how the disease spreads and how communities respond.

Based on the available literature, most of the reports on the pandemic were emphasized on epidemiology studies, vaccine acceptance, public health responses, population density and demographic variables. In India, there has been a significant gap in statistical and quantitative analysis in the categories of sampling design, depth of analysis and longitudinal scope although an extensive research was conducted on perceptions of the healthcare professionals [15]. Most of the reported studies were focused on qualitative analysis rather than quantitative analysis, specifically on vaccination efforts, attitudes, and side-effects, etc. [16-20]. Therefore, it is imperative that more extensive and effective statistical techniques would help to gain a more insights in evaluating the perceptions of healthcare professionals using rank-based methods and concordance measures. One of the few exceptions is a study in Zambia [21], which contrasted the perspectives of 15 health professionals with those of 45 community members on factors driving transmission but its modest sample size underscores how little has been done in this area.

Only a handful of peer-reviewed studies have examined healthcare workers' views on factors driving COVID-19 transmission in the general public, and even fewer have done so comprehensively. Building on this limited evidence base, our survey of frontline workers in Bhopal, Madhya Pradesh, captures their perceptions of community-level spread factors and extends the scope to include key socio-demographic influences and vaccine efficacy, thereby offering a broader and more nuanced perspective than previously reported.

MATERIALS AND METHODS

Data Collection Protocols

To ensure broad participation, a mixed-mode data collection strategy was adopted, utilizing both digital Google Forms and traditional paper-based questionnaires. We acknowledge that mixing data collection modes can introduce potential bias. For instance, digital literacy might influence online responses. To mitigate this, strict consistency was maintained across formats; the phrasing of questions, ranking scales, and language options (Hindi/English) were identical for both groups. The questionnaire consists of 32 questions and has three sections: spread factors of COVID-19, socio-demographic information, and perceptions of vaccine efficacy. The questionnaire contains two types of question, rank-based questions and single-option questions. Forms were distributed among the participants, including doctors, nurses, lab technicians, pharmacists and ambulance drivers working in Bhopal, Madhya Pradesh. Participants who had provided services during the COVID-19 pandemic were only included in the study.

Spread Factors

In this set of questionnaires, we seek to acquire healthcare workers' perception regarding factors and environment contributing to COVID-19 spread, the role of asymptomatic carriers, and the effectiveness of government measures to control the spread.

Socio-Demographic

This section is aimed at capturing the perception of healthcare workers on how socio-demographic characteristics like status, age, gender, and area of residence played a role in the spread of COVID-19.

Vaccine Efficacy

This part of the questionnaire captures the perception of health workers related to vaccine efficacy, vaccine timing, the common factors that affect vaccine acceptance.

Study Design and Participants

A cross-sectional survey design was used to gather data over the period of two months. The study population included healthcare professionals active in Bhopal, Madhya Pradesh. The sample included distinct groups: doctors, nursing staff, laboratory technicians, pharmacists, and ambulance drivers. Before the commencement of the study, ethical obligations were cleared from both the institutional review board and participants. The final data-set consisted of 252 validated responses. This sample size was calculated based on the availability of accessing active-duty staff members during the pandemic response, while ensuring sufficient statistical data for conducting the non-parametric ranking tests applied in the analysis.

Assessment of the Questionnaire

A data of total of 252 eligible participants were collected in this study. Figure **1** distribution of health

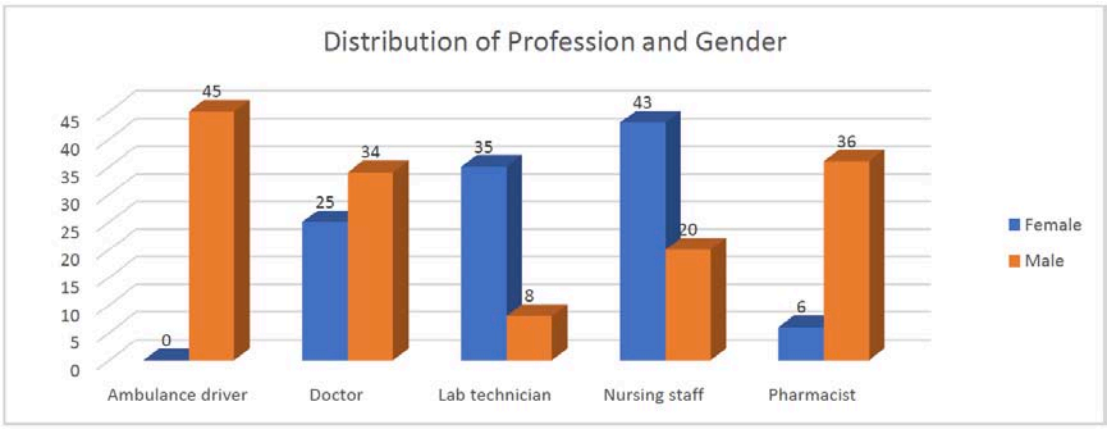

Figure 1: Distribution of health care workers by profession and gender. The bar chart shows the number of male and female respondents across five categories: doctors, nurses, lab technicians, pharmacists, and ambulance drivers.

Table 1: Association of Profession with Age Group

Profession	26–30	31–35	36–40	41–45	46–50	51–55	56–60	Total
Ambulance driver	30	14	1	0	0	0	0	45
Doctor	31	12	10	3	2	0	1	59
Lab technician	11	19	3	8	0	2	0	43
Nursing staff	28	26	7	1	0	1	0	63
Pharmacist	21	14	2	3	0	2	0	42
Total	121	85	23	15	2	5	1	252

care workers by profession and gender. The bar chart in this paper shows the number of male and female respondents classified in five categories: doctors, nurses, lab technicians, pharmacists, and ambulance drivers. shows the count of participants based on profession and gender. Table **1** summarizes the professions of the participants by age group, while Table **2** presents the professions of the participants by experience.

Statistical Analysis

The participants were requested to rank the variables such as spread factors, socio-demographic influences, and vaccine efficacy on COVID-19 transmission and management. To evaluate these rankings, Borda Count method was employed rather than a simple majority voting. A simple vote only highlights the most popular 'first choice', whereas Borda Count aggregates preferences to find the option that is most acceptable to the group as a whole, even if it was not everyone's priority [22]. A robust comparative analysis was performed by using non-parametric tests namely Kendall's Coefficient of Concordance (W_K) and Friedman test [23]. To measure the level of agreement with statistical significance among the professional groups considered in the study, W_K was used. This metric provides a value between 0 (no agreement) and 1 (perfect agreement), allowing to quantify either unified view or fragmented opinions across the selected groups. Also, Friedman test was applied to determine statistically significant differences in rankings among the professionals. The outcome of this test validates distinct priorities identified by each professional cadre by confirming that the observed variations would not be a mere random chance.

Table 2: Association of Profession with Years of Experience

Profession	1–5	6–10	11–15	16–20	21–25	26–30	Total
Ambulance driver	22	23	0	0	0	0	45
Doctor	38	13	5	2	1	0	59
Lab technician	6	25	7	3	1	1	43
Nursing staff	52	9	2	0	0	0	63
Pharmacist	25	9	6	1	1	0	42
Total	143	79	20	6	3	1	252

Data Preparation

The questionnaire has multiple questions, and participants have to rank the options, we used the Borda count for rank aggregation. The purpose of using the Borda count is to identify the most preferred option by participants for each question. The algorithm for the Borda count is shown in Algorithm **1**. Afterwards, we measure the agreement among the participants using Kendall's W coefficient, where 0 indicates no agreement, whereas 1 indicates complete agreement [24]. The Kendall's W measure is computed using Equation **1**. Subsequently, we applied the Friedman test (χ^{2f}) to check the statistical significance of the rank difference [25].

Require: A rank matrix R of size n × m, where n is the number of respondents and m is the number of options.

Ensure: Borda scores S for each option.

1: Initialize S ← [0, 0, . . . , 0] of length m

2: for i ← 1 to m do

3: $S[i] \leftarrow \sum_{j=1}^{n}(m - R[j,i])$

4: end for

5: return S

Algorithm 1: Borda Count Algorithm for Aggregating Rankings.

Equation 1: Kendall's coefficient of concordance (W_K), where n is the number of raters, m is the 99 number of items, R_i is the sum of ranks for item i, and S is the sum of squared deviations from the 100 mean rank 1

$$W_K = \frac{12S}{m^2 (n^3 - n)} ,$$

$$s = \sum_{i=1}^{m} (R_i - \frac{n(m+1)}{2})^2$$

RESULT

We analysed health workers' responses (doctors, nurses, lab technicians, pharmacists, and ambulance drivers) in three domains: Spread factors of COVID-19, sociodemographic factors, and vaccine efficacy. The questionnaire contains two types of questions, rank-based questions and single-option questions. The domain-wise analysis of responses is discussed in the further sub-sections.

Spread Factors

Various factors were assessed to understand health workers' perceptions of what mainly contributed to the spread of COVID-19. Table **3** shows the top spread-related factors ranked by each group of healthcare workers, along with their Kendall's W (W_K) and Friedman test values. Across professions, poor social distancing and public transportation consistently emerged as leading contributors. Doctors and nurses most frequently identified poor social distancing as the primary factor, while pharmacists and lab technicians emphasised crowded places, and ambulance drivers highlighted poor hand hygiene. Agreement was moderate among doctors (W_K = *0.41*), and almost no agreement among nurses (W_K = *0.06*) and pharmacists (W_K = *0.04*). Friedman's test indicated statistically significant variation in rankings among nurses (χ^{2f} = *0.0002*) and lab technicians (χ^{2f} = *0.004*), while agreement among ambulance drivers and pharmacists was non-significant.

Environments of spread were also strongly emphasised. All professions consistently ranked public transportation as the most important contributing environment, with moderate concordance across doctors (W_K = *0.48*), nurses (W_K = *0.40*), lab technicians (W_K = *0.45*), and ambulance drivers (W_K = *0.44*). This indicates strong shared perceptions regarding the role of mobility and transport in accelerating the spread. Friedman's test showed no significant differences, suggesting alignment across groups.

Regarding asymptomatic transmission, doctors, nurses, and ambulance drivers perceived it as "highly significant," while pharmacists and lab technicians considered it "moderate." No ranking statistics were applicable, but the narrative recognises its role across all professions.

When asked about government guidelines, nearly all groups rated compliance with lockdowns and travel restrictions as "extremely important," reinforcing the perceived effectiveness of policy interventions.

Close contact with infected individuals was universally ranked highest for primary transmission risks. Agreement levels were low to no agreement (W_K = *0.20* among doctors, *0.06* among nurses, *0.10* among pharmacists, *0.092* among lab technicians, *0.05* among ambulance drivers). Friedman's test was significant for nurses (χ^{2f} = *0.005*), pharmacists (χ^{2f} = *0.0013*), and lab technicians (χ^{2f} = *0.0032*), suggesting that within these groups, rankings varied across respondents even though close contact was dominant overall.

Most professions perceived travel (domestic and international) as a significant contributor early in the pandemic, though lab technicians were more likely to view its contribution as moderate.

Table 3: COVID-19 Spread Factors and Responses Across Profession

Questions	Doctor			Nurses			Pharmacist			Lab technician			Ambulance driver		
Spread factors	Rank 1	W_K	χ^{2f}	Rank 1	W_K	χ^{2f}	Rank 1	W_K	χ^{2f}	Rank 1	W_K	χ^{2f}	Rank 1	W_K	χ^{2f}
What were the main factors causing COVID-19 spread	Poor social distancing	0.41	0	Poor social distancing	0.06	0	Crowded places	0.04	0.08	Crowded places	0.07	0	Poor hand hygiene	0.03	0.33
Which environments contributed most to COVID-19 spread	Public transportation	0.48	0	Public transportation	0.4	0	Public transportation	0.04	0.1	Public transportation	0.45	0	Public transportation	0.44	0
How much did asymptomatic individuals contribute to COVID-19 spread	Highly significant	NA	NA	Highly significant	NA	NA	Moderate	NA	NA	Moderate	NA	NA	Highly significant	NA	NA
How important was following government guide-lines to control COVID-19 spread	Extremely important	NA	NA	Extremely important	NA	NA	Extremely important	NA	NA	Extremely important	NA	NA	Extremely important	NA	NA
What are the primary risks of COVID-19 transmission	Close contact with infected people	0.2	0	Close contact with infected people	0.06	0.01	Close contact with infected people	0.1	0	Close contact with infected people	0.09	0	Close contact with infected people	0.05	0.07
How much did travel contribute early in the pandemic	Significant	NA	NA	Significant	NA	NA	Significant	NA	NA	Moderate	NA	NA	Significant	NA	NA
Which public health measures were most effective	Lockdowns and quarantines	1	0	Lockdowns and quarantines	0.04	0.04	Lockdowns and quarantines	0.14	0	Mask man- dates	0.12	0	Mask man- dates	0.05	0.08
Which groups were more likely to spread COVID-19	Migrants	NA	NA	Migrants, Low income group	NA	NA	Low-income group	NA	NA	Health workers	NA	NA	Health workers, high income groups	NA	NA
How has public understanding changed since the start	More aware of airborne spread	0.16	0	More aware of airborne spread	0.06	0.01	Higher vaccine acceptance	0.04	0.15	Higher Vaccine acceptance	0.06	0.05	Better hygiene habits	0.13	0
How has public behavior toward measures changed	Much more Compliant now	NA	NA	Much more Compliant now	NA	NA	Much more compliant now	NA	NA	Much more compliant now	NA	NA	Much more Compliant now	NA	NA
Is the public more or less vulnerable now	Less vulnerable	NA	NA	More vulnerable	NA	NA				More vulnerable	NA	NA	More/less vulnerable	NA	NA
Has public health infrastructure improved	Moderately improved	NA	NA	Moderately improved	NA	NA				Moderately improved	NA	NA	Moderately improved	NA	NA
What are the key lessons from the pandemic	Early detection and isolation	0.56	0	Early detection and isolation	0.4	0				Early detection and isolation	0.43	0	Early detection and isolation	0.41	0

*NA-Not Applicable.

Concerning public health measures, doctors, nurses, and pharmacists most often pointed to lockdowns and quarantines, while lab technicians and ambulance drivers emphasised mask mandates. Agreement was highest among doctors (W_K = *1.0*), reflecting near-perfect concordance, while other groups showed lower values but still statistical significance.

Regarding social groups, migrants and low-income populations were frequently mentioned as more likely to spread COVID-19, although lab technicians and ambulance drivers also identified health workers and high-income groups. This response diversity reflects limited consensus and the complexity of social transmission dynamics.

Finally, health workers reported that the public had become more aware of airborne spread since the pandemic, with some groups emphasising vaccine acceptance or improved hygiene habits. Across all professions, compliance with health measures was perceived as much higher now than at the pandemic's start. Vulnerability to infectious diseases was judged variably, with some professions perceiving reduced vulnerability while others noted continued susceptibility. On the infrastructure side, all groups recognised moderate improvements in public health systems, and for long-term lessons, early detection and isolation were unanimously emphasised, supported by moderate concordance among professions (Kendall's W ranging from *0.40 to 0.56*).

Socio-Demographic Factors

The analysis of socio-demographic factors revealed that participants attributed the spread of COVID-19 to different underlying characteristics. Table **4** presents the top sociodemographic factors identified by healthcare workers, with corresponding Kendall's W and Friedman test results. Socioeconomic status was ranked highest among doctors, while public health education was emphasized by nurses. Pharmacists and lab technicians considered age as the most important factor, whereas ambulance drivers highlighted education. Levels of agreement, as measured by Kendall's W, were generally weak (ranging from *0.02 to 0.15*), indicating substantial variability within professional groups. Nevertheless, Friedman's test showed significant differences among nurses (χ^{2f} = *0.001*) and lab technicians (χ^{2f} = *0.0002*). When asked about the demographic groups most responsible for spread, doctors, pharmacists, and lab technicians identified travellers and tourists, whereas nurses highlighted street vendors, and ambulance drivers emphasized essential service workers. Again, consensus was low (W ≤ 0.14), and Friedman's test results indicated significant within-group differences for pharmacists (χ^{2f} = *0.006*) and lab technicians (χ^{2f} = *0.0026*).

Regarding the role of age, opinions diverged: doctors reported no impact, nurses and ambulance drivers felt the elderly spread more, pharmacists viewed both young adults and the elderly as important contributors, while lab technicians pointed primarily to young adults.

For gender, most professions perceived no significant role, though ambulance drivers suggested that women were more likely to spread the virus. On area of residence, doctors believed urban areas were more affected, whereas the other groups tended to see both urban and rural areas as equally impacted. Among those who selected urban areas, crowded public spaces and high population density were consistently highlighted as key contributors, with moderate agreement across groups (W_K = *0.48–0.52*). For rural areas, the most cited contributors were lack of awareness about prevention measures (nurses, pharmacists, lab technicians), social gatherings in close-knit communities (doctors), and limited healthcare access (ambulance drivers). Agreement levels were moderate to strong (W_K = *0.38–0.60*), suggesting clearer patterns of perception in rural contexts.

Vaccine Efficacy

Table **5** highlights the top vaccine-related factors ranked by each profession, along with their Kendall's W and Friedman test values. Across professions, most respondents considered the vaccines to be moderately effective in preventing spread, with ambulance drivers rating them as very effective. In terms of reducing symptom severity, the majority again described them as moderately effective, while ambulance drivers perceived them as highly effective.

All professions consistently identified timing of doses as the most influential factor for vaccine efficacy, with Kendall's W values ranging from *0.04 to 0.09* and Friedman's test indicating significance for doctors (χ^{2f} = *0.0058*), nurses (χ^{2f} = *0.0001*), and ambulance drivers (χ^{2f} = *0.0012*). Respondents agreed that vaccines lost some effectiveness against new variants but continued to provide protection.

Vaccine hesitancy was acknowledged as having negatively impacted campaign success by all groups. Side effects were reported to have increased hesitancy for doctors, nurses, pharmacists, and lab technicians, while ambulance drivers felt side effects had no impact. Regarding booster doses, doctors and nurses described them as somewhat effective, while pharmacists, lab technicians, and ambulance drivers rated them as very effective.

Table 4: Socio-Demographic Factors and Responses Across Professions

Questions	Doctor			Nurses			Pharmacist			Lab technician			Ambulance driver		
Socio-demographic factors	**Rank 1**	W_K	χ^{2f}	**Rank 1**	W_K	χ^{2f}	**Rank 1**	W_K	χ^{2f}	**Rank 1**	W_K	χ^{2f}	**Rank 1**	W_K	χ^{2f}
Which sociodemographic factors most influenced COVID-19 spread	Socioeconomic status	0.15	0	Public health education	0.05	0	Age	0.02	0.36	Age	0.11	0	Education	0.05	0.04
Which demographic group was most responsible for spread of COVID-19	Travelers and tourists	0.14	0	Street vendors	0.07	0	Travelers and tourists	0.06	0	Travelers and tourists	0.06	0	Essential service workers	0.03	0.33
How did age affect COVID-19 spread	Age had no impact	NA	NA	Elderly spread it more	NA	NA	Young adults, Elderly spread it more	NA	NA	Young adults spread it more	NA	NA	Elderly spread it more	NA	NA
Did gender affect the likelihood of spreading COVID-19	Gender did not play a significant role	NA	NA	Gender did not play a significant role	NA	NA	Gender did not play a significant role	NA	NA	Gender did not play a significant role	NA	NA	Women were more likely to spread the virus	NA	NA
Which area was more affected by COVID-19 spread	Urban areas	NA	NA	Both had same impact	NA	NA	Both had same impact	NA	NA	Both had same impact	NA	NA	Both had same impact	NA	NA
If you chose urban areas, what do you think contributed most to the higher spread	Crowded public spaces	0.48	0	High population density	0.52	0	Crowded public spaces	0.48	0	Crowded public spaces	0.51	0	Crowded public spaces	0.5	0
If you chose rural areas, what do you think contributed most to the spread	Social gatherings in closeknit communities	0.38	0	Lack of awareness about prevention measures	0.5	0	Lack of awareness about prevention measures	0.5	0	Lack of awareness about prevention measures	0.56	0	Limited healthcare access	0.6	0

*NA-Not Applicable.

Table 5: Vaccine Efficacy and Responses Across Professions

Questions	Doctor	Nurses	Pharmacist	Lab technician	Ambulance driver	Detailed Explanation
Vaccine efficacy	**Rank 1**	**Rank 1**	**Rank 1**	**Rank 1**	**Rank 1**	
How effective were COVID-19 vaccines in preventing the spread of the virus	Moderately effective	Moderately effective	Moderately effective	Moderately effective	Very effective	Most professions hold a cautious view of transmission prevention, whereas ambulance drivers express higher optimism.
How effective were COVID-19 vaccines in reducing symptom severity	Moderately effective	Moderately effective	Moderately effective	Moderately effective	Highly effective	Clinical staff perceive moderate symptom reduction, while field staff perceive high effectiveness.
What factors influenced COVID-19 vaccine efficacy	Timing of doses	Timing of doses	Timing of doses	Timing of doses	Timing of doses	Universal consensus across all groups that the schedule of administration was the critical determinant.
How did new COVID-19 variants affect efficacy	Vaccines lost some effectiveness but still protected	Vaccines lost some effectiveness but still protected	Vaccines lost some effectiveness but still protected	Vaccines lost some effectiveness but still protected	Vaccines lost some effectiveness but still protected	Broad agreement that variants reduced potency but did not render vaccines ineffective.
Did vaccine hesitancy affect the success of the campaign	Yes	Yes	Yes	Yes	Yes	Unanimous agreement that public hesitancy was a significant barrier to the campaign's success.
How did side effects affect willingness to take second dose/booster	Side effects made people hesitant	Side effects made people hesitant	Side effects made people hesitant	Side effects made people hesitant	Side effects had no impact	Clinical roles observed fear of side effects, whereas drivers did not perceive this as a major hindrance.
How effective were booster doses in improving protection	Somewhat effective	Somewhat effective	Very effective	Very effective	Very effective	Doctors and nurses remain sceptical of boosters compared to the high confidence shown by support staff.
Could vaccines alone have controlled the spread	No, other measures needed	No, other measures needed	Yes, vaccine alone could control	Yes	Yes, vaccines alone could control	Clinical experts emphasize a multi-modal approach; support staff view vaccines as a standalone solution.
How effective are vaccines long-term in preventing severe outcomes	Somewhat effective long-term	Somewhat effective long-term	Somewhat effective long-term	Somewhat effective long-term	Very effective long-term	Drivers remain the most optimistic about long-term benefits compared to other healthcare workers.
How important is it to monitor long-term efficacy	Somewhat important	Very important	Very important	Very important	Very important	Doctors place slightly less emphasis on continued monitoring compared to the strong emphasis from other groups.
How successful was the Vaccination campaign overall	Very successful	Very successful	Very successful	Very successful	Very successful	Universal endorsement of the campaign's overall execution and impact.

*Statistical values for "What factors influenced COVID-19 vaccine efficacy": Doctor (W=0.06, χ^{2f}=0); Nurses (W=0.08, χ^{2f}=0.01); Pharmacist (W=0.04, χ^{2f}=0.14); Lab technician (W=0.04, χ^{2f}=0.09); Ambulance driver (W=0.09, χ^{2f}=0).

On the question of whether vaccines alone could control spread, doctors and nurses emphasized that additional measures were needed, whereas pharmacists, lab technicians, and ambulance drivers believed vaccines alone could suffice. In terms of long-term protection, most groups viewed vaccines as somewhat effective, while ambulance drivers rated them very effective.

Monitoring long-term efficacy was seen as important, with nurses, pharmacists, lab technicians, and ambulance drivers rating it as very important, while doctors described it as somewhat important. Overall, the vaccination campaign was considered very successful by all professions.

DISCUSSION

This study aims to understand the three different aspects of the COVID-19 pandemic: Spread factors, Sociodemographic factors and Vaccine efficacy, from healthcare workers' perspectives. The findings were suggesting that the opinions were not uniform and significant differences were observed within the same groups (Table 1, 2, and 3). For measuring the strength of these opinions, Kendall's W Coefficient test was implemented in which analysis of 11 ranking questions were performed. These statistical values were indicating strong implications on practices and policies to be followed by medical professionals. For instance, a 'weak' agreement describes that different department or profession follows different priorities, resulting in misleading information and therefore, it is imperative to implement standardized training procedures across the departments. On a contrary note, a 'moderate' or 'strong' agreement signifies the execution of unified and effective public health protocols. To achieve this, authors have employed the ranges mentioned in Table 6 to evaluate the practical impact on pandemic management and to interpret the levels of agreement.

The analysis highlighted distinct professional divergences in how transmission factors were perceived.

Spread Factors

There was a common difference between shared beliefs and role-specific perceptions across the professions. All the groups except pharmacists moderately agreed on public transportation ($W_K > 0.4$) as underlying risk of virus transmission. Contrastingly, close contact with infected individuals was not shown statistically significant agreement among groups ($W_K < 0.2$). Furthermore, 'adhering to government guidelines' and 'early detection and isolation ($W_K \geq 0.4$) were found as key insights that need to be focused for future health emergencies like COVID-19, which was a shared agreement among the professions tested. Nevertheless, there was a profound deviation among the perceptions on preventive behaviours. For example, doctors and nurses considered 'poor social distancing' and 'lockdowns' as important drivers whereas pharmacists and lab technicians emphasized more on crowded environments and importance of mask mandates. From the perspective of ambulance drivers, 'poor hand hygiene' and 'direct occupational exposure' were played decisive role in spreading the COVID in uncontrolled areas. Though the discussed deviations underscore complementary viewpoints on the same health crisis, they depict typical reality of each profession involved in this study

Socio-Demographic Influences

In the socio-demographic domain, the diversity of opinion was more pronounced. Doctors viewed

Table 6: Distribution of Kendall's W Ranges Across Sections and Professions

Section	W_K Range	Doctors	Nurses	Pharmacists	Lab Techs	Ambulance
Spread Factors	0.0–0.2 (Very weak)	2	4	5	4	4
	0.2–0.4 (Weak-Moderate)	0	2	1	0	0
	0.4–0.6 (Moderate)	3	0	0	2	2
	0.6–0.8 (Strong)	0	0	0	0	0
	0.8–1.0 (Very Strong)	1	0	0	0	0
	Total	6				
Socio-demographic	0.0–0.2	2	2	2	2	2
	0.2–0.4	1	0	0	0	0
	0.4–0.6	1	2	2	2	0
	Total	4				
Vaccine Efficacy	0.0–0.2	1	1	1	1	1
	Total	1				

socioeconomic status as the most influential factor, nurses highlighted public health education, and pharmacists and lab technicians pointed to age as a key determinant. Ambulance drivers emphasized education level as the main contributor. Despite this variation, there was widespread agreement that travellers and tourists played a central role in spreading infection, while gender was generally not perceived as a major determinant. Most professionals agreed that urban areas were more affected than rural ones, attributing this to high population density and crowded public spaces (W_K: 0.4-0.6). For rural areas, the spread was largely associated with lack of awareness and limited access to healthcare services. These findings underline the importance of public education and equitable healthcare access in pandemic control.

Vaccine Efficacy

The Kendall's W analysis indicates generally low to moderate internal agreement among most professional groups, suggesting that perceptions of COVID-19 varied according to work roles and exposure levels. The most consistent agreement appeared among doctors and nurses, who often chose the same response. The results were indicating that although significant deviations were found in the perceptions of various healthcare professions, preventive behaviours and vaccine benefits were key aspects to control the disease transmission. This convergence of thinking among physicians and nurses (professional in clinical settings) as well as pharmacists, laboratory technicians, and ambulance drivers (professionals in field settings) offers a holistic perspective of the COVID-19 experience in the healthcare system of Bhopal. The timing of doses exhibited a weak agreement ($W_K < 0.2$) across the selected professionals in the study. All the groups strongly agreed on long-term effectiveness of vaccines and its booster doses.

These findings also underline the importance of all healthcare professionals in designing health interventions since each profession participation in the study provided a comprehensive insight into community health behaviour and readiness of systems. The current study observations were found similar to those of international settings though they have some local peculiarities. Consistent with a reported study in Zambia, spread of the virus was mainly attributed to the community behavioural lapses [21]. Nevertheless, in contrast to the situation in Western countries, where vaccine hesitancy is frequently linked to the political factor, the participants of the Bhopal healthcare system reported fear of side effects and logistics (timing of the doses) as the two main obstacles (Table **5**). This is also supported by another study Deressa *et al*. in Ethiopia [26]. The study reported that healthcare workers in Ethiopia stated adhering to safety measures was one of the significant influences to public's failure in managing the COVID-19 transmission. Furthermore, the studies on vaccine hesitancy in the western population was motivated by political beliefs. Whereas in India, the vaccine hesitancy was found influenced side effects of the vaccine and safety concerns, which was similar to the reported study by Vellapally and his co-authors [20].

LIMITATIONS OF THE STUDY

The study results need to be inferred with few limitations. For instance, the conducted research is geographically restricted to the city of Bhopal, India. As a result, the social dynamics and healthcare infrastructure seen in this case might not be ideal indicators of the conditions within large metropolitan centres, which inhabit more people, or in more strictly rural settings which operate under different resource limitations. Thus, the findings might not be completely applicable to other Indian contexts. Also, to some extent we can assume that the study can be gender biased, as the number of male participants was higher than that of female participants. In the current study, ambulance drivers suggested that women were more likely to spread the virus. Thus, the findings might not be completely applicable for the general population, particularly in representing gender-specific perceptions and behaviours. In addition to this, the study may possess age-related bias, as most of the participants were young adults (between 26 and 35 years of age). Therefore, the findings may not adequately represent perceptions and experiences across the entire age spectrum. Another limitation of the study may arise from experience-related selection bias, as most of the participating professionals had relatively short service duration (1–5 years). This may influence risk perception and decision-making patterns, thereby limiting the representativeness of certain viewpoints and reducing the generalizability of the findings to the broader professional population. Moreover, the study emphasises on retrospective evaluation of the past five years experiences that could result in recall bias. The answers of respondents would be influenced by the cumulative professional experience, changing clinical knowledge, and the views that might have been developed after vaccination stage. The perceptions of the participants were suggesting an integrated understanding of pandemic dynamics developed over time although earlier periods were full of uncertainties.

CONCLUSION

This study, conducted among healthcare professionals in Bhopal, Madhya Pradesh, India, provides valuable insight into how different healthcare

roles perceived the COVID-19 pandemic in terms of its spread, socio-demographic drivers, and vaccine efficacy. Overall, there was strong professional consensus on the major transmission mechanisms, the effectiveness of preventive measures, and the essential role of vaccination in reducing severity and mortality. Doctors and nurses showed the closest alignment, reflecting their similar clinical exposure, while pharmacists, lab technicians, and ambulance drivers contributed diverse but complementary views shaped by their operational contexts.

Although differences were noted in behavioural interpretations, perceived vulnerability, and opinions on booster efficacy, all groups agreed that public cooperation, early detection, and sustained vaccination efforts were crucial to pandemic control. These findings, observed within the healthcare environment of Bhopal, emphasize the importance of a multidisciplinary, locally adaptive approach to pandemic preparedness and response. Strengthening communication and coordination across all levels of the health system will be vital in managing future public health emergencies effectively.

Based on current study, three strategic changes can be implemented for future health emergencies like COVID-19. Firstly, the weak agreement among the professionals indicates the necessity for implementation of standardized and integrated training modules. This makes every healthcare cadre from ambulance drivers to surgeons adhere to safety protocols such as hygiene and social distancing equally. Secondly, although policies are frequently based on clinical advice, a change towards field-informed policy-making has been suggested. The involvement of critical feedbacks from field workers like ambulance drivers could help uncover different insights about rural accessibility settings that would otherwise remain unnoticed. Lastly, health authorities should focus on integrating risk communication, which was consistent with resolving the weak agreement on socio-demographic influences. Furthermore, the dissemination of high-risk groups' data among all hospital personnel would help avoid the spread of misinformation and would provide a clear and consistent guidance to the public.

APPENDIX A: SUMMARY OF QUESTIONNAIRE

Section 1: Spread Factors (Format: Rank based and single choice)

Key Questions: ranking factors that contribute to spread (social distancing, hygiene etc.), Ranking Environment (public transport, schools) Assessing the role of asymptomatic carriers.

Section 2: Socio-Demographic based (Rank-Based)

Ranking influences like Socioeconomic Status, Age, Education; Identifying high-risk groups (e.g., migrants, tourists); Comparing Urban vs. Rural spread dynamics.

Section 3: Vaccine Efficacy (Likert Scale and Rank based)

Rating effectiveness of vaccines in preventing spread vs. reducing severity; Ranking factors affecting efficacy (e.g., timing, variants); Assessing vaccine hesitancy and side effects.

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