COVID-19 Combating Strategies and Associated Variables for Its Transmission: An Approach with Multi-Criteria Decision-Making Techniques in the Indian Context

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1 Introduction

The 'Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-2)' was the pathogen's new designation as of February 11, 2020, according to the 'International Committee on Taxonomy of Viruses' [39], whereas COVID-19 was the label given to the outbreak by 'World Health Organization (WHO)'. The following stages of COVID-19 disease transmission include the following: A preliminary phylogenetic study of Stage-1 virus COVID-19 suggested that it may be zoonotic. Stage-2 includes the spreading of COVID-19 to people from animals [3]. Furthermore, the COVID-19 viruses have a 2- to 14-day period of incubation [3, 20, 71] and Stage-3 with the potential for human-to-human transmissions from coughing droplets, contaminated surfaces, or surroundings. Stage-4 will then follow with the COVID-19 epidemic and community transmission [116], and Stage-5 with COVID-19 progressively spreading globally and the number of active cases increasing exponentially [46]. Development of a novel virus suggests that knowledge of dissemination patterns and the related risk factors for infections will be restricted early in outbreaks [125]. Numerous scholarly works have examined COVID-19 prevalence, transmission among people with the disease, and prophylaxis among those patients' close contacts [72].

With the exception of Antarctica, more instances of the coronavirus (COVID-19) have been documented globally since incidences of the disease were first noted in Wuhan (China), in December 2019. The 'World Health Organization' classified

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Z. Hammouch et al. (eds.), *Mathematical Modeling and Intelligent Control for Combating Pandemics*, Springer Optimization and Its Applications 203,
https://doi.org/10.1007/978-3-031-33183-1_13

COVID-19 as an epidemic as a result of the rate of increase exceeding the rate of patients [126]. The SARSCoV-2 is the virus responsible for COVID-19 with around 71,000,000 verified cases and 1,600,000 confirmed deaths worldwide as of December 15, 2020 [126]. When a person who is infected coughs, sniffles, or spits, the virus is discharged from their respiratory secretions. These droplets can infect other persons when they come into touch with them [102]. Most infections are frequently self-limited. In the elderly and those with existing medical conditions, it might lead to more severe sickness [128]. According to current data, fever is present in 88% of cases, exhaustion in 38%, dyspnoea in 18.7%, myalgias in 14.9%, and a dry-cough in 67% of cases at the time of illness's beginning [24, 25]. The most frequent consequence is pneumonia. A mortality rate of 2.3–5% is seen in extreme symptoms [128]. Other than supportive care, there are currently no confirmed particular therapies for people with the new virus. Many patients have obtained off-label and benevolent use medications in China, France, Italy, Turkey, Spain, and now the United States [126]. So far, a variety of strategies have been employed to combat the infection. Currently only few limited vaccines are utilized as the main approaches in India, while the efficacy of various medications is yet uncertain [34, 37, 74, 88].

The virus COVID-19 is regarded as infectious and has been classified as a pandemic. Each country is taking precautions to lessen the rate of transmission after the virus spread to several countries. International health organizations like the WHO routinely issue advisory recommendations urging rigorous action against the causes of COVID-19 transmission. Businesses are seeing the interruption to their supply chain and discrepancy between supply and demand for 'products and services' as a result of the COVID-19 worldwide outbreak. Due to travel restrictions and restricted borders, it is often difficult for enterprises to discover alternate transit and logistic networks. The only approach to identify efficient and secure therapies for COVID-19 and potential future outbreaks is through the quick and concurrent blending of supportive care and arbitrary control trials. The supporting systems that provide decision-makers with the details they need about the options and their attributes are known as 'decision-making models'. The total number of verified cases has recently begun to decline as a result of administrative interventions, enforced controls (like shutting down public transit), adjustments to standard personal hygiene practices (like always wearing a facemask and avoiding physical intimacy), and so on [131]. According to Schippers and Rus [105], resolving the COVID-19 issue might be seriously compromised by group thinking, a limited emphasis on the virus containment issue, and an increase in commitment. The predictions of different responsible factors associated with the pandemic can guide to take precautions accordingly [36, 115]. Despite the exponential global spread of COVID-19, the mortality rate is still manageable, allowing people everywhere to regain their faith in their ability to combat this pandemic collectively. However, only a small amount of scholarly research has examined the causes of the COVID-19 disease's spread among people in various nations [46]. In this situation, a variety of variables contribute to the individuals' COVID-19 infection spread. Therefore, by taking into account only a few variables, policymakers, health authorities, and immunologists cannot determine the level of dissemination and therefore prepare for mitigation. As a result, policymakers and health authorities must conduct a thorough review of the variables contributing to COVID-19's transmission and take all of them into account when developing mitigation and preventative policies. Consequently, methods for 'multi-criteria decision-making (MCDM)' are most appropriate [70].

The following 'research-questions (R-Qs)' were briefly addressed in this chapter:

- R-Q1: What are the main preferences of COVID-19 vaccines among the Indian community?
- R-Q2: What are the essential variables that contribute to the spread of COVID-19?
- R-Q3: Which of them require immediate attention and are the most serious?
- R-Q4: In light of these variables, how should policymakers rank them?

Following is the arrangement for the remaining portion of this chapter. In Sect. 2, the current literature was discussed on COVID-19 vaccinations; COVID-19 transmission variables; and vaccination's reluctances in India. The research methodology used in this chapter was discussed in Sect. 3. In Sect. 4, the results related to the findings was given, which was followed by Sect. 5 with discussion. Finally, in Sect. 6, the conclusion of this chapter was presented.

2 Literature Review

In periods of crisis, the success of policymakers' decisions is highly dependent on their capacity to synthesize and understand information. Governments are faced with the challenging tasks of decision-making in the interests of public safety and health due to the COVID-19 issue. In essence, decision-makers act in response to potential threats whose scopes are unclear while operating under significant time constraints and uncertainties. However, the government should implement an appropriate set of strategies as soon as feasible given that the death rate for serious conditions has been found to be 10% [36]. In a numerical study of COVID-19, Bai et al. [11] analysed the features of the recovery and transmission rate and forecasted the future trend. Decision trees and prior algorithms have been used to analyse the COVID-19 virus's routing information [61], but there is still a potential that some data may be overlooked and more algorithms will need to be included to ensure system results. In a study [8], the spread of COVID-19 in China's Hubei region was anticipated and simulated, but the features of the population, such as the impact of age, the presence of other health issues, and the measures taken to avoid the spread, were not investigated. By using a time-series and kinetic-analysis model, Yichi et al. [129] have demonstrated how the Chinese government's emergency measures, such as its ban on individuals leaving the country, have a significant effect on the spread of the outbreak. As per experimental findings, deceased people's body do not cause further infection, and those who have recovered get benefits from the developed antibodies already present in their systems, which help to avoid future virus replications. According to He et al. [47], the delayed diagnosis of the symptoms and the manufacture of Chinese medication have been identified as the variables leading to the abnormal dynamic characteristics of COVID-19.

Healthcare decision-making involves a sophisticated network of meaningful relationships between several stakeholders [92]. Currently, there are few mathematical models or methods utilized to facilitate the selection of an effective vaccine for combating pandemics and outbreaks. Literature on the variables that could influence a person's decision to accept or reject a vaccination among vaccine alternatives is limited. A clinical decision assistance system has been built using the 'analytic hierarchy process (AHP)' approach [59]. The 'BAILEY's model' was a quantitative decision-making tool utilized by Kumar and Roy [68] in the preclusion and management of COVID-19. Importantly, the criteria and methods for choosing a vaccination among vaccine options are hardly discussed in the literature. Therefore, it is crucial to create a discrete choice model to examine the many selection criteria for vaccines among the options available. The prevention and treatment of worldwide outbreaks all depend on scientific understanding. Some of this information may be condensed in plans for pandemic response and preparation (at both the national and global levels) or may be effectively acquired from panels of experts with knowledge in pertinent fields of study, such as virologists, communicable diseases data analysts, and sociologists [84]. In a catastrophe like the COVID-19 pandemic, the top-government policy experts have a serious decision-making challenge. When a novel infectious illness initially develops, policymakers may try to restrict spreading by quick actions to stop further dissemination. Before the pandemic, the infection was treated with a variety of medications and techniques. Evaluating COVID-19 treatment alternatives by using MCDM techniques have been claimed to be highly valuable because, to yet, no viable treatment option has been discovered and only success was obtained on case based [130]. The COVID-19 virus's properties, such as its virulence, transmissibility, and historical background, were unclear during the outbreak [9]. The dynamics of the system are unclear given the current state of information, which makes the effects of potential policy-actions like shutting institutions or donning masks in public. Policymakers can better appreciate the scope of an issue by considering the different levels of uncertainty, such as uncertainty about-models, across-models, and inside-models [44, 45, 75].

The comprehensive literature on COVID-19's vaccinations, transmission, and variables contributing to its transmission are presented and discussed in the following sections.

2.1 COVID-19's Vaccinations

The COVID-19 pandemic's epicentre has been moving from China to Europe and eventually the United States during the entire year 2020. India has become the new location of the COVID-19 virus's epicentre as the second wave spreads throughout the nation. Since April 2021, India has recorded almost 3 lakh COVID-19 instances every day, which is a more dangerous, and ominous trend than the initial wave. The extremely infectious double mutated version of COVID-19, the simplicity of therapies, and people's careless behaviour are the key causes of this increase in COVID-19 cases [127]. Since COVID-19 (SARS-CoV-2) has a far greater infection rate than previous viruses like 'MERS-CoV and SARS-CoV', it can spread quickly around the world and result in a worldwide epidemic [23]. Droplets, aerosols, and fomites are the principal means of human-to-human COVID-19 transmission [122]. Additionally, according to certain research, COVID-19 dust might also spread via the air [97, 108, 110]. The COVID-19 pandemic's transmission channels, however, are the subject of a contentious disagreement among academics and experts, even if everyone in the globe abides by WHO norms. To prevent exposure to the virus, it is crucial to adopt preventative measures such hand washing, quick isolation of patient's with symptoms or diagnosed, social distance, and the use of sanitizers and masks [29]. Even with the aforementioned measures, this illness continues to have a high mortality rate and afflict all nations in the world [90]. The transmission of COVID-19 is attributed to a number of variables, including social distances [63], climate-related variables [55], safety- and hygiene-related variables [35], and cognitive variables [101]. Therefore, it is necessary to employ various preventatives and control techniques, both locally and globally.

There are about 30 vaccine contenders being developed in India, all at different levels. Two are at the most advanced level of these. These include 'COVAXIN' from the 'Indian Council of Medical Research (ICMR)' and alliance with 'Bharat Bio-tech', as well as 'COVISHIELD' from 'Serum Institute of India (SII)' [82, 96]. The 'National AIDS Research Institute (NARI)' in Pune and the ICMR are responsible for overseeing all studies. The 'Department of Biotechnology (DBT)' and the 'Department of Science and Technology (DST)' are funding other vaccine alternatives that are in various research stages [21, 78, 79]. Six of these potential vaccines are now undergoing clinical trials. The preclinical trial stage is being experienced by the remainder [119]. The 'COVISHIELD', 'COVAXIN', and 'Sputnik-V' are the leading contenders. A phase-III human clinical study for COVISHIELD, a non-replicating adenovirus type-5 vector-vaccine, is now taking place in India. A locally created complete virion inactivated vaccine called COVAXIN is also undergoing Phase III human clinical trials. On January 3, 2021, the 'Central Drugs and Standards Committee (CDSCO)' formally authorized both of these vaccination candidates [117, 119]. Sputnik-V vaccine began Phase-III in the first week of August 2020 after successfully completing the Phase-II study. This Russian-based vaccine, created by the 'Gamaleya Research Institute', is based on the common cold virus and has demonstrated the ability to stimulate the production of antibodies by the immune system [82]. Larger human studies are being conducted there, and this vaccine will also be produced there [83]. The subsequent creation of a successful and enhanced approach is largely dependent on the discovery of the

COVID-19's transmission variables. As a result, this chapter aims to identify and describe the potential sources of COVID-19 viral transmission through the existing literature.

2.2 COVID-19's Transmission Variables

According to research findings, it is crucial to keep COVID-19 from spreading by maintaining good cleanliness, safety, sensitivity, social, demographic, and psychological variables. In the next sub-sections, the major and significant COVID-19's transmission variables are elaborated.

2.2.1 Climate-Related Variables

Climate-related variables including air quality, temperature, wind speed, rainfall, humidity, and solar radiation help the new COVID-19 virus spread quickly [4, 67]. Relative humidity, temperature, and wind speed are significant determinants in the spread of COVID-19, according to an analysis by Chen et al. [24, 25] regarding the link between environmental conditions and the severity degree of transmission. According to Wang et al. [123], who studied how temperature affects COVID-19's transmission, low-temperature nations should enact strict control measures to stop COVID-19's transmission. In humid continental locations, warmth periodicity also promotes COVID-19's transmission favourably [95]. Furthermore, research shows that the COVID-19's transmission is influenced by the relative humidity and everyday temperatures [51]. A few studies, for example, found that low humidity may have facilitated COVID-19's transmission [10, 123]. For limiting the spread so that the heart and lungs can fight off the infections, the relatively high humidity (>95%) is recommended [65]. However, other investigations discovered that the rate of COVID-19's transfer and wind speed had an inverse association [13]. As a result, the transmitting rate is increased when the wind blows more slowly. In addition to transfer from person to person, Coccia [28] found that air pollution may speed up the spread of COVID-19.

2.2.2 Safety- and Hygiene-Related Variables

First and foremost, everyone who has had direct touch with a COVID-19 patient is at high infection risks [125]. According to recent studies, those who are infected with the COVID-19 virus but do not exhibit any symptoms (i.e. those who are asymptomatic) are also responsible for spreading the disease [50]. On February 17, 2020, 189 asymptomatic travellers out of 1723 travellers tested positive for the COVID-19 virus [85]. The 'personal protective equipment (P.P.E.)' such as 'masks and face-shields' help to safeguard medical professionals from COVID-19 patients, while also protecting the general public [112]. The WHO has previously issued a warning on the serious disruptions of the availability of P.P.E. products on a worldwide scale and urges business and governments to enhance output by about 40% to satisfy the growing demand on a global scale. The COVID-19 illness can spread widely through the air and surfaces, in both ‘intensive-care units (I.C.U.)’ and to medical-ward designated COVID-19, according to Guo et al. [41], suggesting a significant potential danger of spreading among the physicians and medical staffs. Therefore, it is essential to have a sufficient and timely supply of P.P.E. to reduce the transmitting rates. Additionally, used tissues, masks, gowns, and gloves from households and hospitals that are medical wastes might potentially spread the dangerous COVID-19. As a result of routinely handling unlabelled wastes properly, the sanitation workers and rag pickers are vulnerable to COVID-19’s infection.

2.2.3 Making Decisions with Attentiveness

Worldwide, significant behavioural-based intrusions have been made to slow the development of COVID-19 [64]. To slow the pace of transmission, some nations have issued full travel bans [40], lockdowns [66], and forced quarantines [94]. Due to decreased vehicle traffic and better air quality in several Indian cities, lockdown has had a considerable beneficial influence on lowering COVID-19 transmission and pollution levels [53]. In the provinces of Wuhan and Ezhou, China implemented a lockdown on January 23, restricting all public transportation and social activities. Many nations announced border control measures to stop visitors from China after the WHO designated COVID-19 a global health emergency on January 30, 2020. A 14-day obligatory quarantine period and a ban on international travellers from China, Hong Kong, and Macao were implemented by the Philippines on February 2, 2020 [31]. Impact of human travel and mobility on the transmission of the COVID-19 virus was examined and shown to be extensive by Gondauri and Batiashvili [38]. Additionally, delays in COVID-19 identification and quarantine have accelerated COVID-19 spread [124]. To prevent the spread of COVID-19 and increase response to the existing overburdened healthcare systems, governments in several nations are officially enforcing quarantines and travel restrictions.

2.2.4 Social- and Demographic-Variables

Social cohesion (mass assembling), density of population, and age range are the primary social- and demographic-variables [76]. Religious events, panic-related movements, worker interstate travel, and other conditions can cause large crowds, which can speed up the spread of COVID-19. For instance, in China, the COVID-19 epidemic occurred at the same time as the Lunar New Year celebrations. From Wuhan city, the COVID-19 epicentre, it was projected of five million people travelling to the world’s various parts [24, 25]. From another occurrence, several pilgrims who had attended massive prayers in Iran and returned to Pakistan tested positive for COVID-19, and amid the COVID-19 crisis, over 10,000 pilgrims congregated in Bangladesh for prayer. In Malaysia, there have been more than a hundred new COVID-19 infection cases since a large meeting in Kuala Lumpur in February 2020. According to statistics, the Sri Pentatig mass gathering was directly responsible for more than 35% of the COVID-19 cases in Malaysia [22]. Nearly 30% of COVID-19 cases in India were linked to large religious gatherings, according to studies. To prevent social gatherings, the majority of countries quickly closed places of worship, retail centres, workplaces, and cancelled sporting events. As a result, huge religious assemblies and religious tourism are among the major causes of COVID-19 spreading [86]. High population density may be another important demographic variable contributing to the COVID-19 virus spreading more quickly. Researchers discovered a link between the COVID-19 transfer rate and population density [107]. Mumbai is the most severely impacted city in India because of its dense population and most of its locations are quite susceptible to COVID-19 infection [57]. Using a mask and maintaining a distance from others are two self-protective behaviours that have been shown to reduce individual infection risk and stop the spread of disease [93]. Unfortunately, social distance regulations (such as suspending activities, shutting down companies and schools, and issuing orders to stay at home) have a terrible financial and societal impact [2, 17].

2.2.5 Psychological-Related Variables

Every pandemic has an impact on a person's psychology, and thus making people aware of them, providing health-related education, and taking preventative actions to minimize disease spread are crucial [56]. For instance, Ilesanmi and Alele (2020) investigated the impact of Ebola virus infection's knowledge, attitudes, and perceptions among Nigerians. Their findings indicate that the majority of the population lacked awareness and had a poor attitude about the viral spread. Similar to this, Roy et al. [103] conducted a survey of regular people to evaluate their awareness of, attitudes about, and practices related to the COVID-19 epidemic. According to their research, social isolation, knowledge of COVID-19, travel restrictions, quarantine, and hygiene precautions were crucial. The majority of participants concurred that taking these precautions and cultivating a positive outlook might aid in preventing the potential illness. Participants expressed anxiety and dread over the reintegration of recovering patients into society. As a result, the community's behaviour has been impacted by the dread and worry caused by the extremely contagious COVID-19. Ample public knowledge is thus required in order to influence people's attitudes toward recovering patients and prevents social discriminations [32].

2.3 Vaccination's Reluctances in India

The digital gap is more pronounced in India, where a sizeable section of the population lives in rural areas without access to formal schooling [19, 109, 118]. This suggests that vaccination reluctance may perhaps be more prevalent than previously assumed. According to a study, between 29% and 39% of Indians were unwilling to get vaccines at the beginning of 2021 [27]. Another longitudinal study conducted from January to June of 2021 indicated that 12.7% of adult Indians will not receive the COVID-19 vaccination [120]. Other studies have discovered that worries about the safety and adverse effects of the current vaccinations are the main causes of vaccine reluctance and rejection in India [30]. The COVID-19 vaccine awareness programmes and communication should be based on research, regionally targeted, culturally appropriate, multifaceted, and led by politicians, healthcare experts, dependable voices from the area, and role models. In the extremely varied India's population, researches need to be made on the best ways in spreading the benefits in receiving the COVID-19's vaccine, as well as to alleviate fears and eliminate misunderstandings and misleading facts [60, 104].

Nearly half of Indians have acquired at least single dose of the COVID-19 vaccination by October 2021 [91]. India will now have to deal with COVID-19 resistant and reluctant groups when vaccination rates stagnate [12, 111]. Government should see COVID-19 vaccine reluctance as a severe public health concern. Even a small percentage of vaccine scepticism in India might result in millions of COVID-19 vaccination-refusing citizens throughout the country, which would encourage the emergence of new variations and frequent outbreaks for a very long period.

3 Research Methodology

This research involved an exhaustive literature analysis, followed by interaction with healthcare specialists to identify the underlying vulnerabilities with the COVID-19 pandemic outbreak in Indian context. Moreover, in order to address the aforementioned global health issues, further in-depth investigation is needed to pinpoint and examine the causes of COVID-19's transmission globally. In this chapter, the decision-making model for vaccine's selection was made based on the appropriateness of the available vaccines for COVID-19 patients in the setting of India with various comorbidities. The experts evaluated the vaccine's suitability in terms of four criteria, including the following: vaccine's availability that relies on its ease of access and manufacturing-location; vaccine's effectiveness [77], which can increase the value of vaccine; the likelihood of vaccine-related adverse effects, which may be severe or moderate, and their frequency; and cost savings that include vaccine, transport, and storage costs; respectively [1].

Additionally, despite the fact that other MCDM methods have been established, or the discovery of criteria's estimates and picking in view of their proclivities, one

Table 1 Characteristics of expert participants

Healthcare expert's competence areas	Sexual orientation		Years of experience (average)
	Male	Female	
Pulmonologist	10	2	Beyond 20
Neurologist	6	3	Beyond 16
General physician	3	2	Beyond 23

of the most popular methods that utilize comparisons was already considered as the 'Best-Worst Method (BWM)' with even less data needs and more trustworthy comparability [98]. Rezaei et al. [100] observed that the BWM is suitable when there are fewer criterions to be taken into consideration and that it also produces more consistent findings with fewer pair-wise comparisons [80]. The 'SWARA (Step-wise Weight Assessment Ratio Analysis)' approach, another MCDM method that can handle a variety of criteria in any complicated situation, has also demonstrated its unique use for diverse decision-making processes [81, 134]. Additionally, various research has recommended combining MCDM methods to effectively manage more complex problems, such as SWARA and the 'complex proportional assessment (COPRAS) method' [133]; and SWARA and 'VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) analysis' [6]. However, there are not many researches that take complicated problems into account when integrating BWM and SWARA methods. Therefore, in this chapter, a novel effort was made by combining two MCDM methods, such as the BWM and SWARA methods in order to rank the significant variables that contribute to spreading of COVID-19.

Initially, considering the existing availability, the main preferences of COVID-19's vaccines, such as 'COVISHIELD', 'COVAXIN', and 'Sputnik-V' among the Indian community was done by the use of SWARA approach. Further, in order to rank the essential and significant variables that contribute in spreading COVID-19 and according to how best to prioritize them, the associated significant variables were ranked using the BWM technique. Further, the associated sub-variables were ranked using the SWARA approach, which took into account the variable's optimized-weight values when determining the final weight values of the corresponding sub-variables. The 26 experts who participated in the decision-making stages for the research are enumerated in Table 1, along with information about their typical years of experience, higher education, and sexual orientation.

3.1 The Associated Variables and Sub-variables Identification for the COVID-19 Pandemic Transmission

According to literature, and experts' views, the COVID-19's transmission variables and the corresponding sub-variables were identified as depicted in Table 2.

Table 2 Summary of COVID-19 pandemic transmission variables and the corresponding sub-variables

Sl. no.	Variables	Sub-variables	Source(s)
1	Climate-related variables (V1)	Air-quality ($SV1_1$) Temperature ($SV1_2$) Rainfall ($SV1_3$) Humidity ($SV1_4$) Wind-speed ($SV1_5$)	Ahmadi et al. [4]; Coccia [28]; Hossain [49]; Wang et al. [123]
2	Safety- and hygiene-related variables (V2)	Unawareness of hygiene ($SV2_1$) P.P.E.'s shortages ($SV2_2$) Spitting ($SV2_3$) COVID patient's waste disposals ($SV2_4$) Close contacts ($SV2_5$)	Ghernaout and Elboughdiri [35]; Sohrabi et al. [113]; Vordos et al. [121]
3	Making decisions with attentiveness (V3)	Quarantine-delay ($SV3_1$) Lockdown-delay ($SV3_2$) Travel-restrictions ($SV3_3$)	Chinazzi et al. [26]; Kludge et al. [62]; Nicola et al. [89]; Sohrabi et al. [113]
4	Social- and demographic-variables (V4)	Social-discrimination and -cohesiveness ($SV4_1$) Age-group ($SV4_2$) Population-density ($SV4_3$)	Ahmed and Memish [5]; Bavel et al. [14]; Chen et al. [24, 25]; Mufsin and Muhsin [87]
5	Psychological-related variables (V5)	Knowledge, attitude, and activities ($SV5_1$) Impulsive purchases ($SV5_2$) Concealing past travels ($SV5_3$)	Bavel et al. [14]; Chakraborty and Maity [18]; Ho et al. [48]; Zhong et al. [132]

The five sub-variables under 'Climate-related variables (V1)' included 'Air-quality ($SV1_1$); Temperature ($SV1_2$); Rainfall ($SV1_3$); Humidity ($SV1_4$); and Wind-speed ($SV1_5$)'. The five sub-variables identified under 'Safety- and hygiene-related variables (V2)' included 'Unawareness of hygiene ($SV2_1$); P.P.E.'s shortages ($SV2_2$); Spitting ($SV2_3$); COVID patient's waste disposals ($SV2_4$); and Close contacts ($SV2_5$)'. Similarly, three sub-variables identified under 'Making decisions with attentiveness (V3)' included 'Quarantine-delay ($SV3_1$); Lockdown-delay ($SV3_2$); and Travel-restrictions ($SV3_3$)'. The three sub-variables under 'Social- and demographic-variables (V4)' included 'Social-discrimination and -cohesiveness ($SV4_1$); Age-group ($SV4_2$); and Population-density ($SV4_3$)'. The three sub-variables under 'Psychological-related variables (V5)' included 'Knowledge, attitude and activities ($SV5_1$); Impulsive purchases ($SV5_2$); and Concealing past travels ($SV5_3$)'; respectively.

3.2 The Actions Undertaken in BWM

As noted by Rezaei [99], the following actions were portions of the BWM:

Action-1 A collection of decision-criteria was formed, comprising of 'n' distinct criteria as: $\{C_1, C_2, \ldots, C_n\}$, based on a literature review and the opinions of experts.

Action-2 From the most important or most enviable criterion and the least important or least enviable criterion, the 'worst-criteria (WC) and best-criteria (BC)' were selected.

Action-3 Using values between '1 and 9', it was decided that the BC should take precedence over all other factors. The resulting 'best-to-others (BTO)' vector was provided by: $A_{BC} = \{a_{BC1}, a_{BC2}, \ldots, a_{BCn}\}$, where, $a_{BCi} =$ BC's choice over j, and $a_{BCBC} = 1$.

Action-4 Similar to previous action, other criteria's choices over WC were obtained. The resulting 'others-to-worst (OTW)' vector was provided by: $A_w = \{a_{1W}, a_{2W}, \ldots, a_{nW}\}^T$, where, $a_{jWC} =$ j's choice over WC, and $a_{WCWC} = 1$.

Action-5 The 'optimized-weights (AI_W)' that were found were $\{WC_1^*, WC_2^*, \ldots, WC_n^*\}$.

Calculating AI_w for minimizing the greatest absolute-differences, that is, $\{|WC_{BC} - (a_{BCj}WC_j)|, |WC_j - (a_{jWC}WC_{WC})|\}$ for all j was the primary goal of this stage. The 'minimax-model' that resulted was as follows:

$$\text{Minimax } \{|WC_{BC} - (a_{BCj}WC_j)|, |WC_j - (a_{jWC}WC_{WC})|\}$$

Subject to,

$$\sum_j WC_j = 1, \{WC_j \geq 0 \text{ for all } j\} \tag{1}$$

Then, continuing with 'Model-(1)', the following linear model was developed:

$$\text{Minimax } \xi^*$$

Subjected to,

$$\begin{gathered} |WC_{BC} - [a_{BCj}WC_j]| \leq \xi^*, \quad |WC_j - a_{jWC}WC_{WC}| \quad \{\text{for all } j\} \\ \textstyle\sum_j WC_j = 1, \quad \{WC_j \geq 0 \text{ for all } j\} \end{gathered} \tag{2}$$

The aforementioned 'Model-(2)' was solved to determine AI_W as well as the 'optimized-value (ξ^*)'. A number 'closer to 0' was essential for evaluating the comparison's 'consistency (C_i^*)', which was another key consideration [100].

Table 3 Values of C_I in BWM

a_{BCWC}	9	8	7	6	5	4	3	2	1
C_I (Maximum ξ^*)	5.23	4.47	3.73	3.00	2.30	1.63	1.00	0.44	0

However, the C_I in Eq. (3) below helps to determine the C_i^*.

$$C_i^* = \left[\xi^*/C_I\right] \tag{3}$$

The values of 'consistency-index (C_I)' that were utilized, was as shown in Table 3.

3.3 *The Stages Undertaken in SWARA*

The subsequent stages, according to Stanujkic et al. [114], were used to prioritize more and less crucial factors.

Stage 1 Clustering the criteria according to order of importance

In this stage, experts evaluated the proportional weights assigned to each criterion to rate them. The more significant criterion was initially placed first, and only then was the less significant criterion added in the end destination.

Stage 2 Assessing how relevant typical values are in comparison

Depending on how important criterion (c_j) was in comparison to criterion (c_{j+1}), the relative-importance of 'average values (s_j)' was established beginning with the criterion that has been placed second.

Stage 3 Coefficients' (k_j) computation as given:

$$k_j = \begin{cases} 1, & j = 1 \\ s_j + 1, & j > 1 \end{cases} \tag{4}$$

Stage 4 Recalculated-weights' (q_j) calculation as stated below:

$$q_j = \begin{cases} 1, & j = 1 \\ \frac{q_{j-1}}{k_j}, & j > 1 \end{cases} \tag{5}$$

Stage 5 Final weights' (w_j) computation of the 'evaluation-criteria' for n number of criteria, as given:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \tag{6}$$

Table 4 w_j of available vaccines

Vaccines	Relative-importance of s_j	k_j	q_j	w_j	Rank based on w_j value
COVAXIN		1	1	0.396	1
COVISHIELD	0.21	1.21	0.826	0.327	2
Sputnik-V	0.18	1.18	0.700	0.277	3

4 Results

The ranking of the available vaccine's preferences in India and the COVID-19 transmission variables with the corresponding sub-variables was described in the following sub-sections.

4.1 *Ranking of the Available Vaccine's Preferences in India*

The w_j values of different available vaccines were obtained by using SWARA approach as illustrated in Table 4. It may be noted the experts' suggestion were taken for sorting the available vaccines according to their preferences. The ranking based on w_j values of different vaccines revealed the preference for COVAXIN at first level, which was followed by the subsequent preferences for COVISHIELD and Sputnik-V at second and third levels.

4.2 *Ranking of the COVID-19 Transmission Variables and Corresponding Sub-variables*

4.2.1 Variable's Ranking by BWM

The BC and WC were chosen based on the experts' opinion and the respective importance of each of the five selected Vs. Then, on a scale of '1 to 9', experts were interviewed to decide which variables were favoured as BC over all others. By using the same evaluation values, the opinions of other variables associated to the WC were also established. Additionally, the AI_w values for each of the criteria in addition to the C_i^* was derived using the 'BWM-Solver.xlsx software', and equation (ii) was used to finalize the preference scores for all five Vs.

The variable V2 was chosen as the BC and V2 as WC. Table 5 illustrated the comparisons of V2 to all Vs, while Table 6 illustrated the comparisons of all Vs to V5. Table 7 illustrated the AI_w values for each variable, such as $AI_{w1} = 0.229$; $AI_{w2} = 0.448$; $AI_{w3} = 0.114$; $AI_{w4} = 0.153$; and $AI_{w5} = 0.054$. Additionally, C_i^* was found to be 0.011, as shown in Table 7. Then, taking criterion on X-axis and values of AI_w on Y-axis, a graph was created as shown in Fig. 1. The AI_w

Table 5 The comparison of V2 to all Vs

BTO	V1	V2	V3	V4	V5
V2	2	1	4	3	8

Table 6 All Vs comparison to V5

OTW	V1	V2	V3	V4	V5
V5	4	8	2	3	1

Table 7 Vs' AI_w values

Vs	AI_w	C_i^*	Rank
V2	0.448	0.011	**1**
V1	0.229	**2**	
V4	0.153	**3**	
V3	0.114	**4**	
V5	0.054	**5**	

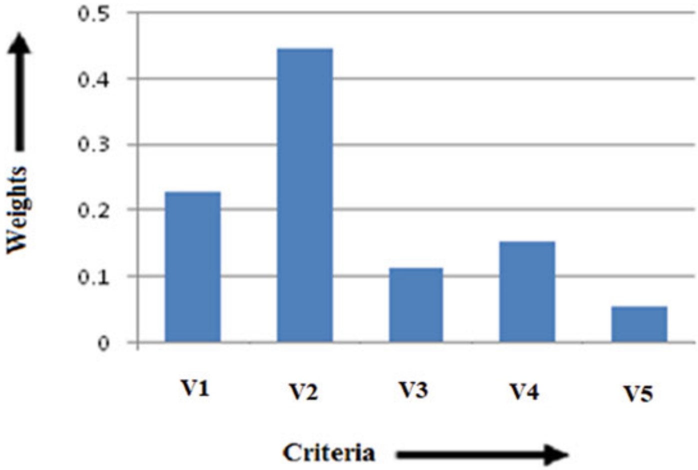

Fig. 1 Values of AI_w for all Vs

for different Vs revealed that 'Safety- and hygiene-related variables (V2)' to be rated in the first level, and was followed by 'Climate-related variables (V1); Social- and demographic-variables (V4); Making decisions with attentiveness (V3); and Psychological-related variables (V5)'; respectively.

4.2.2 Sub-variable's Ranking by SWARA

The 'final revised-weight (FRw_j) values' for each of the sub-variables under each of the different Vs were calculated using the AI_w of the various Vs found in BWM as presented in Tables 8, 9, 10, 11, and 12, respectively. The FRw_j of each sub-variable was calculated using the AI_w [58]. It should be mentioned that the experts'

Table 8 FRw_j of all sub-variables of V1

Sub-variables	Relative-importance of s_j	k_j	q_j	w_j	#FRw_j
$SV1_5$		1	1	0.269	0.061
$SV1_4$	0.20	1.17	0.854	0.229	0.052
$SV1_1$	0.18	1.18	0.724	0.194	0.044
$SV1_2$	0.19	1.19	0.608	0.163	0.037
$SV1_3$	0.15	1.15	0.529	0.142	0.032

#FRw_j of, $SV1_4 = 0.229 \times 0.229 = 0.052$; $SV1_3 = 0.142 \times 0.229 = 0.032$

Table 9 FRw_j of all sub-variables of V2

Sub-variables	Relative-importance of s_j	k_j	q_j	w_j	FRw_j
$SV2_1$		1	1	0.258	0.115
$SV2_5$	0.15	1.15	0.869	0.224	0.100
$SV2_4$	0.13	1.13	0.769	0.198	0.088
$SV2_2$	0.16	1.16	0.663	0.171	0.076
$SV2_3$	0.15	1.15	0.576	0.148	0.066

Table 10 FRw_j of all sub-variables of V3

Sub-variables	Relative-importance of s_j	k_j	q_j	w_j	FRw_j
$SV3_1$		1	1	0.390	0.044
$SV3_3$	0.19	1.19	0.840	0.327	0.037
$SV3_2$	0.16	1.16	0.724	0.282	0.032

Table 11 FRw_j of all sub-variables of V4

Sub-variables	Relative-importance of s_j	k_j	q_j	w_j	FRw_j
$SV4_3$		1	1	0.379	0.058
$SV4_1$	0.15	1.15	0.869	0.329	0.050
$SV4_2$	0.13	1.13	0.769	0.291	0.044

Table 12 FRw_j of all sub-variables of V5

Sub-variables	Relative-importance of s_j	k_j	q_j	w_j	FRw_j
$SV5_1$		1	1	0.384	0.020
$SV5_3$	0.17	1.17	0.854	0.328	0.017
$SV5_2$	0.14	1.14	0.749	0.288	0.015

Table 13 Final weight's summary

Variables and sub-variables	AI_w and FRw_j	Variable's ranking based on AI_w	Sub-variable's ranking based on FRw_j
V1	**0.229**	**2nd**	–
$SV1_1$	0.044	–	**10th**
$SV1_2$	0.037	–	**11th**
$SV1_3$	0.032	–	**12th**
$SV1_4$	0.052	–	**8th**
$SV1_5$	0.061	–	**6th**
V2	**0.448**	**1st**	–
$SV2_1$	0.115	–	**1st**
$SV2_2$	0.076	–	**4th**
$SV2_3$	0.066	–	**5th**
$SV2_4$	0.088	–	**3rd**
$SV2_5$	0.100	–	**2nd**
V3	**0.114**	**4th**	–
$SV3_1$	0.044	–	**8th**
$SV3_2$	0.032	–	**7th**
$SV3_3$	0.037	–	**11th**
V4	**0.153**	**3rd**	–
$SV4_1$	0.050	–	**9th**
$SV4_2$	0.044	–	**10th**
$SV4_3$	0.058	–	**7th**
V5	**0.054**	**5th**	–
$SV5_1$	0.020	–	**13th**
$SV5_2$	0.015	–	**15th**
$SV5_3$	0.017	–	**14th**

recommendations were followed regarding the respective importance of the sub-variables under the various Vs.

Following the above calculations, Table 13 provided a summary of the weights assigned to each relevant variables and sub-variables, together with their relative rankings in relation to the AI_w and FRw_j values. It was observed that the safety- and hygiene-related variables ranked at first level, which was followed by climate-related variables; social- and demographic-variables; making decisions with attentiveness; and psychological-related variables. The sub-variables in the descending order of ranking included the following: Unawareness of hygiene; Close contacts; COVID patient's waste disposals; P.P.E.'s shortages; Spitting; Wind-speed; both Lockdown-delay and Population-density; both Humidity and Quarantine-delay; Social-discrimination and -cohesiveness; both Air-quality and Age-group; both Temperature and Travel-restrictions; Rainfall; Knowledge, attitude and activities; Concealing past travels; and Impulsive purchases; respectively.

5 Discussion

As COVID-19 spreads, it poses a serious threat to government agencies and decision-makers worldwide [52, 54]. There is a pressing need for effective and safe vaccinations as a result of this continued growth [43]. Public health initiatives to encourage the usage of the vaccine as a means of putting an end to the deadly pandemic might be seriously undermined by external forces that have an influence on the vaccine approval process [16]. Consideration of several psychological and social variables is necessary for the recommended and widespread acceptance of vaccines [106]. Irrespective of vaccination effectiveness, it has been demonstrated that COVID-19's vaccine allocation for older persons (more than 60 years) resulted in subsequent decrease in mortality [33]. According to a study on the vaccination habits of nurses, nurses' COVID-19-related job demands were linked to greater work stress and, as a result, a larger intention to get the COVID-19's vaccine [69]. The COVID-19 pandemic highlights the difficulties that governments and international organizations have in deciding which feasible interventions will be most successful. The best available scientific data, which is often offered by expert opinions and relevant studies, would be combined to create the logical strategic decision [7, 15, 42].

The ideal course of action is for the decision-makers to consult vaccination experts in addition to experts in other disciplines, such as for analysing cost-analysis and social-factors. Depending on the characteristics of the system and other important factors, a decision may require a certain group of experts [73]. The choice of vaccination by the public can undoubtedly be influenced by media coverage, but decision-makers' views should not be impacted by it [1].

6 Conclusion

This chapter provided a novel hybrid MCDM framework to identify variables and sub-variables that are responsible for COVID-19's transmission. In order to rank the significant variables that contribute to spreading of COVID-19, an effort was made by combining both the 'Best-Worst-Method (BWM)' and 'Step-Wise Assessment and Ratio-Analysis (SWARA)' methods establishing a hybrid MCDM framework. Apart from this, it also analysed the existing available vaccines preferences among the Indian community. A 'safe and healthy' environment can be achieved by revising healthcare plans and policies in light of the results and underlying consequences. This work has several shortcomings despite these original contributions; thus, it provides some suggestions for further research. First of all, because COVID-19 is a novel virus that may transmit in a variety of ways, virology and observational studies are still in their infancy. The analysis can be repeated in the future with the addition of new variables and sub-variables that affect COVID-19's transmission.

Conflict-of-Interest Statement The authors declare of having no conflict of interest.

Funding Information There was no funding for this research.

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