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Review Article

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Optimizing the Impact of Vector-Borne Diseases in India Through the Best-Worst Multicriteria Decision-Making Method for Prioritizing Their Distribution Based on Impact Factor

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ABSTRACT
The term mosquito-borne disease refers to diseases transmitted by mosquitoes. Emerging or re-emerging diseases occur in a previously uninfected region, group, or individual. Several infectious diseases can cause dengue, chikungunya, Zika, West Nile fever, and malaria, for example. As a result of competent mosquitoes and frequent travel to endemic areas, these diseases are likely to emerge or re- emerge in India. Several factors affect the distribution of vectors and/or diseases, including climate conditions, meteorological conditions, the environment, and demographic factors. Several countries with similar environmental conditions such as China, Nepal, Pakistan, Bangladesh, and Bhutan are examined in this paper. It will also identify mosquito vector introductions or spreads. Multicriteria decision-making is used in India to prioritize diseases. In accordance with PRISMA guidelines, we identified, selected, and evaluated relevant studies. 223 of the 469 articles identified in the databases were reviewed. 47 articles between 2000 and 2017 were included in the data set. In the papers, dengue, zika, and chikungunya were discussed. Population density, precipitation, and temperature influenced results. Temperature, precipitation, and NDVI are the most commonly used variables. In 23% of the articles, temperature, precipitation, and water indexes were the largest variables. Recent publications on mosquito-borne diseases indicate that mosquito-borne diseases are becoming more important in India. Environmental and climatic factors influence emerging diseases' spatial distribution and emergence.

Introduction

India is one of the countries with the highest number of vector-borne diseases. These diseases can cause a wide range of illnesses, such as dengue fever, malaria, chikungunya, and Zika virus, after being transmitted by vectors such as mosquitoes, ticks, and flies. Many factors influence the transmission of these diseases, including the environment, demographics, and human behavior [1]. As India's population increases, urbanization increases, and climate patterns change, vector-borne diseases have become one of the biggest challenges for the public health system [2].

During the last few years, India has made significant progress in controlling and preventing the spread of vector-borne diseases. Although the country is making progress in achieving its health-related development goals, there is still a long way to go. There can be a significant impact on morbidity and mortality associated with these diseases, particularly in vulnerable populations. To ensure the continued development of the country and the wellbeing of its citizens, it is essential to minimize the impact of vector-borne diseases in India [3-5].

In India, optimizing the impact of vector-borne diseases is critical by prioritizing their distribution based on their impact factors [6,7]. It is a systematic approach for determining the most important factors that contribute to the distribution of vector-borne diseases in India using the best-worst multicriteria decision-making method. With this method, it is possible to rank and prioritize factors according to their impact factor, which will aid in developing effective interventions and control measures [8,9].

A best-worst multicriteria decision-making method can help you decide when multiple factors need to be considered. By using this approach, decision makers can compare a set of criteria against each other and identify the factors that are most important. Using this method, decision-makers are asked to select the best and

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worst criteria among a set of alternatives by performing a series of pairwise comparisons [10-12]. In this way, each criterion is ranked according to its relative importance, and the process is repeated until a ranking of the criteria has been obtained [13-15].

A multicriteria decision-making method known as best-worst has been used in many fields for decision-making and resource allocation, such as healthcare, transportation, and environmental management [16,17]. Vector-borne diseases in India are influenced largely by environmental conditions, demographic factors, and human behavior, such as human behavior. Using this method can help identify these factors. Effective interventions and control strategies can be developed by identifying those risk factors that have the greatest impact on the health of individuals based on their impact factor [18,19].

In this article, we explore current literature on the transmission of mosquito-borne diseases in India and neighbouring countries, as well as factors that may affect their transmission risk [20,21]. The study will also identify the factors that have the potential to influence the introduction or spread of mosquito vectors. This study will examine factors related to the environment and climate, including climate change effects. The distribution of vector-borne diseases in India will be prioritized using the best-worst multicriteria decision-making method. To minimize India's vulnerability to vector-borne diseases, the studies will help develop effective strategies for public health intervention and control [22,23].

For the country to continue to develop and ensure the wellbeing of its citizens, it is imperative to minimize the impact of vector-borne diseases [24,25]. As a result, it is extremely important to prioritize their distribution based on their impact factors. The best-worst multicriteria decision-making technique can assist in this process by identifying the most important factors contributing to the distribution of vector-borne diseases in India [26,27]. The purpose of this study is to develop effective interventions and control strategies for vector-borne diseases in India by analyzing both environmental and climatic factors. The primary research question of this paper focuses on identifying and prioritizing vector-borne diseases in India [24,27]. The following research questions are included:

RQ1. Which vector-borne diseases are prevalent in India, and what factors influence their distribution and impact?
RQ2. How can vector-borne diseases in India be prioritized based on their impact factors using the best-worst multicriteria decision- making method?
RQ3. To prioritize the distribution of vector-borne diseases in India, what should be the key factors that should be considered, and how should these factors be weighted?
RQ4. To prioritize the distribution of vector-borne diseases in India, how can the best-worst multicriteria decision-making method be used?
RQ5. To inform public health officials and policymakers, what are the most effective ways to communicate the results of a best-worst multicriteria decision-making approach?

This research aims to identify and prioritize vector-borne diseases in India to optimize their impact [41]. Specifically, we aim to:

Q1. An assessment of the impact of vector-borne diseases on health, social, and economic aspects of the country is intended to identify the key vector-borne diseases prevalent in the country.
Q2. The purpose of this study is to determine the criteria that should be considered when prioritizing vector-borne diseases in India based on their impact factors.
Q3. The aim of this study was to develop an impact-based multicriteria decision-making method for prioritizing the distribution of vector-borne diseases in India, based on their impact factors.
Q4. Validate the results by consulting experts and applying a best-worst multicriteria decision-making model for addressing vector- borne diseases in India.
Q5. Analysing the performance of multicriteria decision making to optimize vector-borne diseases in India based on best-worst decision making.

In the remainder of this paper, the following structure will be followed: section 2 summarize the Literature Review (Optimizing the impact of vector-borne diseases in India in India), section 3 Methodology (best-worst multicriteria decision-making method), section 4 outlined the Results (ranking of impact factor), section 5 Discussion (implications for optimization, comparison with previous studies), and in last section 6 Conclusion (key findings, recommendations, limitations, future research).

Literature Review

For this study, a literature review identified 47 articles published between 2000 and 2017 that were relevant to vector-borne diseases in India ("Disease Prevention and Outbreak Response Cell (DPORC) Centre for Community Medicine All India Institute of Medical Sciences, New Delhi 1," n.d.). The major mosquito-borne diseases prevalent in India are dengue, chikungunya, Zika virus, West Nile fever, and malaria. As a result of the review, it has become evident that climatic and environmental factors play a vital role in determining the distribution of mosquito vectors as well as the risk of disease emergence or reemergence [28,29]. West Nile virus and its vectors have been mainly studied using temperature, precipitation, and NDVI, while temperature, precipitation, and population density were found to be significant risk factors for dengue, chikungunya, and Zika virus transmission [30]. As a result of the review, the number of publications related to mosquito-borne diseases has increased in recent years, indicating a growing interest in these diseases in India [31]. An effective strategy for prioritizing vector-borne diseases distribution based on impact factor must be developed, as indicated by the literature review and the discussion of other vector- borne diseases in India [32,33].

Impact Factor for Distribution Different Vector-Borne Disease

Each field has an impact factor that measures the importance of specific research studies. An article's impact on the scientific community is determined by how many times it is cited by other researchers [34]. It has been suggested that impact factors can be used as a means of prioritizing the distribution of vector-borne diseases in India according to their potential impact on the health of the public [35]. Impact factor is used in this context to identify the most relevant and high-quality studies on vector-borne diseases and assess their significance to the scientific community. Studies like these can provide valuable insights into the epidemiology, transmission, and prevention of vector-borne diseases, and their findings can assist public health policies and interventions [36]. By identifying the factors that are most likely to cause transmission of a particular vector-borne disease, it is possible to prioritize efforts to prevent its spread. It is equally possible to guide policy decisions and resource allocation through studies that evaluate the effectiveness of a particular intervention strategy [35]. Public health efforts can be focused on the most significant and pressing vector- borne diseases by using impact factor to prioritize disease distribution in India. An approach such as this can help optimize the impact of interventions and resources, improving public health outcomes and vector-borne disease control [34].

Research Gap

Even though vector-borne diseases have been significantly reduced in India, they remain a major public health concern, especially in rural areas. As a result of a lack of systematic and evidence-based approaches to prioritize the distribution of vector-borne diseases according to their impact factor, many interventions have been implemented to control the spread of these diseases. However, these interventions have still proven limited effective.

It is important to note that there has been little research to date that explores the use of the best-worst multicriteria decision-making method in reducing the impact of vector-borne diseases in India. Existing studies often focus on traditional decision-making methods, such as cost-effectiveness analysis or resource allocation, which ignore the multidimensional nature of the problem. Moreover, few studies have examined the ethical implications of prioritizing vector-borne diseases based on their impact factor and their potential negative impact on other sectors, such as agriculture and tourism.

Additionally, there is a gap in the literature regarding the adaptability of best-worst multicriteria decision-making to other public health challenges in India and elsewhere. There has been application of the technique in many fields, including environmental management and business, but it has not been fully explored in the public health field.

Research gaps must be addressed for vector-borne disease control in India to inform evidence-based decision-making and resource allocation. An effective vector-borne disease distribution can be evaluated and prioritized using a best-worst multicriteria decision- making approach based on the impact factor, and resources can be allocated accordingly. As part of this approach, ethical considerations can be considered and the potential impact on other sectors assessed. Furthermore, exploring its potential as a tool for effective resource allocation and decision-making in the public health sector may provide insight into its adaptability to other public health challenges.

Research Methodology

In this study, we propose a two-phase framework for evaluating the impact of vector-borne diseases in India by utilizing the best-worst multicriteria decision-making method in order to prioritize their distribution based on their impact factors. To optimize the impact of vector-borne diseases in India, the first phase of the study is dedicated to reviewing the literature and extracting the relevant impact factors and sub-impacts. Optimizing the impact of vector-borne diseases impact factor and sub-impact factor are calculated using the Best Worst Method (BWM). It is the empirical study method that is used to aid expert opinion in the assessment of those challenges and sub-challenges that need to be discussed in Phase II. In Phase II, Indian experts were asked to provide a quantitative assessment of the impact factor's significance. All of the sub-impact factors are categorized into five groups based on their impact factors. An empirical study based on data collected from surveys further validates the findings of BWM. According to Figure. 1, the research methodology is outlined in a flow diagram.

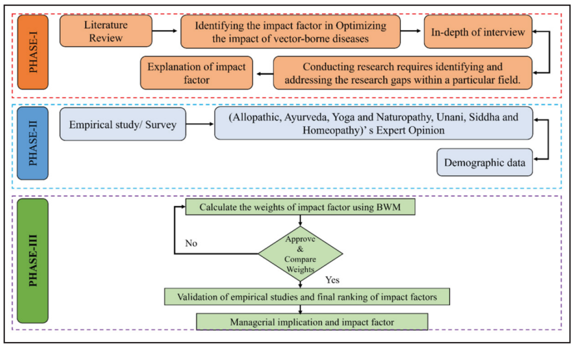

Figure 1: The flow diagram illustrating the methodology of the research

Search Strategy

There are several factors that can affect the impact of vector-borne diseases in India, including those identified in AB's paper, as well as those related to impact, challenges, diseases, or risks. During this study, a search was conducted in the Scopus and Web of Science (WoS) databases to support the findings [37,38]. The bibliometric data available from these databases is widely recognized as the most effective method for retrieving bibliometric data from many high- impact journals. Scopus and WoS generated a combined total of 469 publications (n = 246 and 223) by excluding irrelevant topics like immunology, microbiology, dentistry, and psychology; peer-reviewed articles were restricted to "English", and the study excluded irrelevant fields such as immunology, microbiology, dentistry, and psychology. Based on the data examined, 200 duplicate articles were identified and removed from the review using the Systematic Review Assistant-Deduplication Module (SRA-DM). 167 articles were retained after a further screening based on their titles and abstracts of the remaining 102 articles [1]. Following that, the key portions of the articles were scanned to identify related articles. As of this writing, only 63 papers have been identified as relevant at this point in the investigation. According to the PRISMA flow diagram Figure 2, 71 articles were retrieved in full text and four were screened in full text [39].

Identification and Finalization of Impact Factor

This study was conducted using an extensive and systematic approach based on expert opinion and a thorough literature review to identify and finalize impact factors. As a result of our literature review, we initially identified disease burden, economic impact, environmental impact, and social impact as potential factors affecting disease burden. We then conducted a series of interviews with experts in the field of vector-borne diseases in India to gather their opinions on the most important impact factors. As we refined and finalized the list of impact factors, the experts provided valuable insights on their relevance and importance. Among the final set of impact factors were disease prevalence and mortality rate, disability-adjusted life years (DALYs), economic burden, environmental impact, and social impact. Public health, the environment, and the economy in India have been affected by vector-borne diseases because of these factors.

Systematic and comprehensive approaches are necessary to identify and finalize impact factors to ensure the best-worst method's accuracy and validity. To improve the accuracy of our prioritization outcomes, we employ a rigorous approach to identify the most relevant and important impact factors. Best-worst multicriteria decision-making methods for optimizing vector-borne diseases' impact in India require identification and finalization of impact factors. We highlight the importance of identifying and finalizing impact factors in a systematic and comprehensive manner, which can improve the accuracy and validity of prioritization.

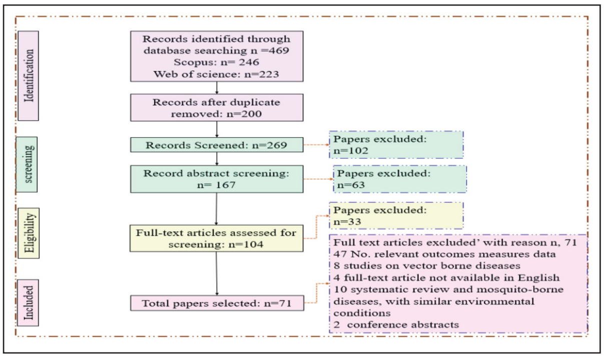

Figure 2: Prisma flow diagram of the several impact factor

Table 1: Optimizing the impact of vector-borne diseases in India is associated with the following impact factor

Category	Impact Factor	Describe	Code	Sources
Environment	Climate	The weather patterns and temperature ranges that support vector survival and reproduction	E1	[1,2,39]
	Land use	The ways in which humans modify and use the environment that may impact vector populations and behavior	E2	[3,4,40]
	Water sources	The presence and availability of standing water, which may serve as breeding sites for some vectors	E3	[5-7]
	Socioeconomic factors	Conditions related to poverty, education, access to health care, and cultural practices that affect the risk of infection	E4	[8-10]
Vector	Species diversity	Diversity and abundance of vector species determine their competence, behavior, and interaction with other species, as well as the complexity of control interventions.	V1	[11,12]
	Genetics	Genetic variability of vectors and pathogens can affect their susceptibility, resistance, adaptation, and evolution, as well as the effectiveness of vector control methods.	V2	[13,14]
	Behavior	Feeding preferences, host-seeking, and resting behavior of vectors influence their contact with humans, as well as the transmission efficiency and location of pathogens.	V3	[1,39,40]
	Seasonal abundance	The frequency and timing of vector presence and activity throughout the year	V4	[3,5]
	Distribution	The geographic range of the vector	V5	[6-8]
Host	Susceptibility	Susceptibility of human and animal hosts to infection and disease depends on their immune status, genetics, behavior, and nutrition, as well as the presence and abundance of co-infecting agents.	H1	[9-11]
	Mobility	Mobility and migration of human and animal hosts influence their exposure, contact, and transmission of pathogens, as well as the spatial distribution and spread of diseases.	H2	[2,12,13]
	Socioeconomic status	Socioeconomic status and cultural practices of human hosts affect their access to healthcare, hygiene, education, and information, as well as their perception and behavior towards vector- borne diseases.	H3	[22,23]
	Immunity	The ability of an individual to resist or recover from an infection	H4	[24-26]
Pathogen	Type	The microorganism that causes the disease, such as bacteria, virus, or parasite	P1	[27,41]
	Virulence	The severity of the disease caused by the pathogen	P2	[42]
	Drug resistance	The ability of the pathogen to withstand the effects of drugs used to treat the disease	P3	[43,44]

Category	Impact Factor	Describe	Code	Sources
Pathogen	Diversity	Diversity and variability of pathogens affect their transmission dynamics, clinical manifestations, and vaccine development, as well as the complexity of diagnostic and surveillance systems.	P4	[45,46]
	Evolution	Evolutionary changes of pathogens, such as antigenic drift and shift, drug resistance, and host adaptation, can affect their virulence, transmissibility, and control, as well as the risk of emergence and re-emergence.	P5	[47-49]
	Co-infection	Co-infection of multiple pathogens in vectors or hosts can affect their transmission, pathogenesis, and diagnosis, as well as the interaction and competition among pathogens.	P6	[28,50]

It is important to note that these barriers are interrelated and can affect each other. Addressing these barriers will require a collaborative effort from all stakeholders involved in facility management, including building owners, facility managers, technology providers, and regulators.

Explanation of impact factor

Environment

In India's diverse ecosystem, vector-borne diseases are becoming increasingly prevalent. As disease control moves forward, a revolution is emerging, called Best-Worst Multicriteria Decision-Making (BW-MCDM) [1]. The environmental impact factor is the driving force behind this transformational approach. The paper provides an in-depth examination of the complex interaction between vectors, pathogens, and niches in the environment [39]. Identifying high-impact regions optimized resources and maximized outcomes. Incorporating vectors, climate patterns, and human dynamics into this novel methodology transcends conventional approaches [40]. It provides decision-makers with a symphony of data-driven insights to prioritize distribution and target areas most at risk of disease outbreaks. Human well-being and the natural environment can coexist harmoniously with this method in urban and rural settings [4,5]. The dawn of this new era is bringing about a transformational path towards controlling vector-borne diseases. As a result of the enlightened lens of environmental impact factors, India strives to maintain the fragile balance of the environment and safeguard its citizens' well-being [7].

Vector

The Vector Impact Factor has emerged as the new game-changing concept in the fight against vector-borne diseases in India [6]. The Best-Worst Multicriteria Decision-Making method underpins this innovative approach to disease control. The identification of high-impact regions can be achieved by considering vectors, their habitats, and their impact on disease transmission [8]. The result is the ability to target interventions and allocate resources more efficiently. Using the Vector Impact Factor, we can prioritize disease distribution by considering factors such as the abundance of vectors, the competence of vectors, and the interactions between vectors and humans. India, as it embraces this novel approach, will be able to do more to mitigate vector-borne diseases, fostering a healthier future for all through implementation of the Vector Impact Factor [9].

Host

The Host Impact Factor is being sought by India as a breakthrough in the field of vector-borne diseases. This innovative concept redefines disease control strategies by using a Best-Worst Multicriteria Decision-Making process as its compass [16]. The identification of regions with a high host impact can be achieved through the analysis of host characteristics, behaviors, and susceptibility [17]. Having access to this knowledge allows targeted interventions to be made and resources to be allocated efficiently. Using the Host Impact Factor, one can prioritize diseases based on host population density, immune response, and socio-economic factors. It is important to note that as India embraces this paradigm shift, the Host Impact Factor will serve as a driving force, paving the way for the combat of vector-borne diseases and ensuring the health of its diverse population [18].

Pathogen: There is one pivotal concept that emerges from the relentless effort in India to combat vector-borne diseases: the Pathogen Impact Factor. This revolutionary approach to disease control is based on the Best-Worst Multicriteria Decision-Making technique [11]. To identify areas with high pathogen impact, it is necessary to assess pathogen characteristics, virulence, and transmission dynamics. As a result of this knowledge, targeted interventions can be made, and resources can be allocated more efficiently. In addition to considering factors such as pathogen prevalence, resistance to treatment, and genetic diversity, the Pathogen Impact Factor provides an overall framework for categorizing diseases in order of priority [12]. The Pathogen Impact Factor will become increasingly important as India embraces this transformative approach, guiding the fight against vector-borne diseases and safeguarding the public's health [13].

Empirical Study

Survey Design

The purpose of a survey is to obtain information and judgment from medical experts in a laboratory and research manner based on the identified criteria using grounded theory analysis. This survey is designed in three parts, which aim to gather both expert judgments and information; (1) biographic information, which collects information such as the expertise and job title of the experts; (2) close-ended judgments, in which the experts examine the identified criteria from the first phase and determine whether they are appropriate; (3) open-ended judgments, in which the experts are asked to provide additional judgments, such as grouping two criteria. A close-ended judgment requires the experts to provide their judgment using the following linguistic terms: "Strongly disagree", "Strongly disagree", "No opinion", "Agree", and "Strongly agree", allowing the experts to express their opinions in a consistent manner and avoiding the need for precise and crisp judgments by the experts listed in Table 2.

Table 2: Results of the empirical analysis (*n* = 127)

No.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	*n* = 127	Utility value
E	3	5	15	65	39	127	-1.067
E1	4	6	4	61	52	127	1.085
E2	5	5	8	58	51	127	1.085
E3	1	4	7	65	60	137	1.038
E4	6	6	6	32	77	127	1.104
V	4	4	4	49	66	127	1.067
V1	8	6	5	69	39	127	-1.124
V2	5	3	4	36	79	127	1.067
V3	4	4	5	48	66	127	1.067
V4	6	5	4	53	59	127	1.095
V5	4	6	6	49	62	127	1.085
H	3	4	4	62	54	127	1.058
H1	2	3	5	56	61	127	1.041
H2	6	2	6	52	61	127	1.067
H3	4	5	4	54	60	127	1.076
H4	6	6	7	49	59	127	1.104
P	4	4	5	56	58	127	1.067
P1	6	3	6	49	63	127	1.076
P2	4	1	4	53	65	127	-1.041
P3	3	6	7	69	42	127	-1.076
P4	4	4	6	71	42	127	1.067
P5	5	5	5	52	60	127	1.085
P6	4	4	6	63	50	127	1.067

Pilot test

Prior to conducting the data collection process, a pilot test is conducted to determine the usability of the questionnaire survey. During the pilot test, eight experts from universities (SRM Polytechnical University, SRM school of public health) and Hospital (SRM global hospital, Chennai, India) were invited to participate. They were sent an email containing a sample questionnaire survey showing in Table 3. According to the experts, additional information should be included about the experts' work experience, consistency of their responses should be checked, and judgments of experts should be collected in tabular form. The questionnaire has been updated in response to expert suggestions.

Table 3: Expert weight calculation score

Aspect	Class	Score
Title	Senior	4
	Intermediate	3
	Associate	2
Experience	Junior	1
	Over 20 years	4
	10-19 years	3
	5-9 years	2
	Under 5 years	1

Data Collection

To verify the criteria identified in the first phase, we collected the opinions of medical experts through a questionnaire survey. For reaching the targeted vector borne disease, such as experts in the field of used hospital and medical or laboratory research acquisition, we use ResearchGate, email, and social media such as LinkedIn and WhatsApp. Additionally, snowball sampling is used to reach the target disease. After carefully reviewing the responses to this survey, it was determined that eight are incomplete and should therefore be excluded. 127 responses were analyzed in the following analysis.

Data analysis using Best worst approach

A frequency analysis is performed on the collected responses after obtaining the survey data, and criteria with low support from experts are removed from the analysis. We also analyze and use the open-ended information gathered from the responses [1].

Best-worst analysis can be used to assess how vector-borne diseases might affect other sectors, such as agriculture and tourism, based on the distribution of vector-borne diseases. As part of this technique, participants select from a list of options which factors are most influential in making their decision and determine which are most important [40].

Policymakers and public health officials may find it helpful to use the best-worst method to determine the impact that prioritizing vector-borne disease distributions may have on other sectors. As an example, prioritizing the distribution of vector-borne diseases in agriculturally productive areas can lead to significant economic losses due to a reduction in crop yields [3]. Vector-borne diseases could also negatively affect local businesses and economies in tourist-heavy areas if they are prioritized for distribution.

Public health priorities can be better balanced with other stakeholders' needs and concerns if policymakers understand the potential impact of prioritizing the distribution of vector-borne diseases [5]. The broader implications of vector-borne disease control strategies may be considered this way, ensuring that decisions are made fairly, ethically, and sustainably.

To determine the weights for the criteria, we use five steps in the BWM.

Step 1: the process consists of defining a set of criteria that will be used in making the decision.
Step 2: Using the list established in the first step, the decision-maker/expert determines which criteria are the best (B) and the worst (W).
Step 3: A pairwise comparison is conducted to determine which criteria is preferred by the decision-maker/expert between 1 and 9, where 1 means equally important and 9 means much more important as shown in Table 4. There are also intermediate evaluations indicated by the other numbers. A vector AB is obtained as the result of this step by adding the vectors a_{B1}, aB2, a_{Bj}, a_{Bn}, where aBj represents the preference for criterion B over criterion j. Eq. (4).

Table 4: The consistency indices for the BWM

X_{bm}	1	2	3	4	5	6	7	8	9
Consistency Index	0	0.44	1	1.63	2.3	3	3.73	4.47	5.23

Step 4: The 1 to 9 scale is used to determine the preference for the other criteria over the worst criteria. The vector Aw = (a_{1W}, a_{2W},..., a_{jW},……, a_{nW}) represents the outcome of Step 4, where ajW is the preference for criterion j over criterion W [5,10,11].
Step 5: we consider the final criteria. In this mathematical model, weights are computed for the criteria (w, w, w) based on the mathematical model.

Results

In this study, we conducted a literature review to explore 18 factors that contribute to vector-borne disease transmission. It is possible to identify the vector-borne disease impact factor in three steps by applying the empirical technique: (i) assembling a panel of expert advisors, (ii) identifying the relevant importance of these vector-borne disease impacts, and (iii) comparing the best impact factor to the others, and the other impact factor to the worst challenge. There are two subsections in the results section: the first describes the findings from the Best-Worst Method, while the second discusses the empirical verification of those findings.

Findings from Best-Worst Method

The Best-Worst Method requires clustering of challenges due to many impact factors. As a result of these factors, we have classified them into three clusters. These are Environment (E), Vector (V), Host (H) and Pathogen (P). The experts were consulted in a third round for the purpose of comparing these three clusters. The experts offered mixed opinions as to which cluster would have the greatest impact and which would have the least impact. According to Table 5 and Table 6, there is a mixed opinion among the experts about these three clusters and their ratings of the best-to-the-others and worst-to-the-others. As shown in Eq. 1, after optimizing the LPP model. In Table 7, we have calculated the optimal weightage of all these three clusters and determined a minimum value for each expert's opinion (Table 7). There should be a very close relationship between the consistency ratio and zero for the pairwise comparison. This value indicates that the consistency ratio is very small and close to zero. For the global weighting and ranking of sub- impact factors, the weights of these three clusters are used.

For the BWM, the sub-impacts within each cluster are also considered. Based on the average weight calculated for all respondents, the experts identify the best and worst impacts in each cluster of sub-impacts and determine the local optimal weights for each impact. We use the weights of all three clusters to determine the global optimal weights of these sub-impacts as weighted average values (Table 8) once we have determined the local optimal weight and the local ranking of all the sub-impacts within each cluster. To determine the global ranking for each sub-criteria, the global weights of the sub-impacts are considered. There are three tables in Appendix A that compare the best-to-others and the others-to-the-worst for the sub impact and the optimal local weights observed during BWM.

Table 5: Impact factor for 7-respondents for category

Impact Factors	1	2	3	4	5	6	7
Worst →	P	V	H	E	H	V	P
E	7	2	3	5	8	3	4
V	3	1	2	8	6	7	6
H	2	1	3	2	5	3	1
P	2	3	4	5	6	8	7

Table 6: category for 7-respondents of impact factors

Respondent S.no	Best ↓	E	V	H	P
1	E	7	8	2	3
2	P	1	8	7	3
3	V	8	4	6	5
4	H	6	7	6	7
5	P	8	4	5	3
6	E	5	1	6	4
7	V	6	3	2	5

Table 7: Best and worst criteria of each aspect

Aspect	Best Criterion	Worst Criterion
Environment	Socioeconomic factors (E1)	Water sources (E4)
Vector	Seasonal abundance (V1)	Species diversity(V4)
Host	Socioeconomic status (H1)	Mobility (H4)
Pathogen	Type(T4)	Drug resistance (T4)

Table 8: Global weights and ranking of impact factors

Category	Weight	Barriers	Code	Local Weight	Local Rank	Global Weight	Global Rank
Environment	0.2264549	Climate	E1	0.2255	2	0.0511	7
		Land use	E2	0.2181	3	0.0494	9
		Water sources	E3	0.2007	4	0.0454	13
		Socioeconomic fac-tors	E4	0.3557	1	0.0806	1
Vector	0.2698296	Species diversity	V1	0.1570	4	0.0424	17
		Genetics	V2	0.1619	3	0.0437	14
		Behavior	V3	0.2567	2	0.0693	4
		Seasonal abundance	V4	0.2674	1	0.0722	3
Host	0.2329525	Distribution	H1	0.2435	2	0.0567	5
		Susceptibility	H2	0.2140	3	0.0498	8
		Mobility	H3	0.2105	4	0.0490	10
		Socioeconomic status	H4	0.3321	1	0.0774	2
Pathogen	0.270763	Immunity	P1	0.1601	4	0.0433	15
		Type	P2	0.1912	1	0.0518	6
		Virulence	P3	0.1707	3	0.0462	12
		Drug resistance	P4	0.1481	6	0.0401	18
		Diversity	P5	0.1565	5	0.0424	16
		Evolution	P6	0.1734	2	0.0470	11

Table 9: Comparison of the BWM results with the empirical study

Category	Barriers	Code	Mean	Ranking through empirical study	Ranking Through BWM method
Environment	Climate	E1	3.8	7	7
	Land use	E2	3.61	9	9
	Water sources	E3	3.52	13	13
	Socioeconomic factors	E4	4.3	1	1
Vector	Species diversity	V1	3.21	17	17
	Genetics	V2	3.45	14	14
	Behavior	V3	4.16	4	4
	Seasonal abundance	V4	4.19	3	3
Host	Distribution	H1	4.09	5	5
	Susceptibility	H2	3.74	8	8
	Mobility	H3	3.6	10	10
	Socioeconomic status	H4	4.26	2	2
Pathogen	Immunity	P1	3.39	15	15
	Type	P2	3.98	6	6
	Virulence	P3	3.54	12	12
	Drug resistance	P4	3.12	18	18
	Diversity	P5	3.3	16	16
	Evolution	P6	3.59	11	11

Statistical validation of findings As we have considered only nine experts while ranking challenges using BWM, our findings cannot be generalized. It is also necessary to conduct an empirical study to validate the findings of BWM. Responses from 107 professionals with experience in the medical research expert and medicine sectors were collected and rated on a 5-point scale the importance of different influencing factors. 7 respondents were from abroad (one from the USA, one each from Africa, Bangladesh, Malaysia, Australia, and China) out of 107 who took part in the survey. A total of seven respondents are included in this study, of which two members are from the industry of medicine and the other five come from academia and hospitals with hospitality expertise. These seven respondents are all Indians and have a very good understanding of the Indian domestic conditions. A total of 80 Indian respondents participated in the survey, 36 of which were from the Delhi NCR (National Capital Region) and the remaining 44 respondents came from different parts of India, including Pune, Mumbai, Hyderabad, Chennai, etc. Based on their experience, 56 respondents are from industries such as the pharmaceutical industry, hospitals, and academia, while 34 respondents are from academia and work in areas such as medical laboratories and (Allopathic, Ayurveda, Yoga and Naturopathy, Unani, Siddha, and Homeopathy) development.

In Appendix B, you will find the questions that were asked of the 87 respondents. A closed-ended questionnaire was used to collect the responses both online and offline. Using a five-point rating system, challenges are ranked according to their importance. In Table 9, Column 3, you will find the mean rating for all responses. Table 9 presents the results of this empirical study and BWM in terms of the ranking of challenges. It has been observed that impact factor rankings are quite similar with both approaches. It is observed that, when analyzing using BWM, the environment impact factor receives the highest ranking, but when analyzing empirically, it receives the second highest ranking. The vector impact factor has received the third ranking in both analyses. Furthermore, it is found to be the most significant factor influencing India's ability to optimize its impact on vector-borne diseases.

Both analytic and empirical studies correlate the rankings of factors impacting the optimization of vector-borne diseases in India, such as dependency on a high concentration of vectors. Using the empirical study, host factors with a higher impact factor were ranked sixth, whereas they were ranked seventh when measured by BWM. In both the BWM analysis and the empirical study, the rest of the impact factors have almost identical rankings. As a result, we can conclude that the findings of BWM are also supported by the findings of the survey.

Discussion

Vector-borne diseases in India can be optimized using the worst-to-best multicriteria decision-making method. It is possible for policymakers and public health officials to allocate resources more effectively and efficiently by systematically evaluating and prioritizing vector-borne diseases by their impact factor, thus reducing the burden on society and public health [5,8]. Considering the multidimensional character of the problem is one of the key advantages of the best-worst multicriteria decision-making method.

A more comprehensive understanding of vector-borne diseases can be achieved by considering a range of factors, including public health, social and economic factors [32,38]. In addition to its flexibility and adaptability, the best-worst method is a multicriteria decision-making method that is based on multiple criteria. As this approach is customizable to suit the needs and circumstances of different regions and public health challenges, it can be used for a variety of purposes in the field of public health [1]. For prioritizing the distribution of vector-borne diseases, using the best-worst multicriteria decision-making method is subject to several limitations and challenges. As an example, the method relies on accurately and complete data to assess criteria, which in some circumstances is difficult to obtain [11,14].

It is also possible for bias and subjectivity to result from the selection of the most important and least important criteria due to differences in perspectives and values among participants. The importance of transparency and engagement with stakeholders throughout the decision-making process is shown by this example, which ensures that all perspectives are considered and that decisions are made fairly and equally [15,16]. Although it comes with its own set of challenges, the best-worst multicriteria decision-making method is an invaluable tool for minimizing the impact of vector- borne diseases in India. As a result of considering the multifaceted nature of the problem and providing a comprehensive understanding of vector-borne diseases, this approach can reduce the burden of public health and society by enabling more informed decision-making and resource allocation [17].

Implications

In India, the use of the best-worst multicriteria decision-making method affects the optimization of disease distribution based on vector- borne diseases. It is more efficient and effective to allocate resources based on impact factors rather than purely on their ability to reduce the burden of these diseases on society and the public health if decision-makers and public health officials systematically evaluate and prioritize criteria based on their impact factors [14,15].

The need for a comprehensive assessment of criteria is one of the key implications for optimization. In addition to public health factors such as disease prevalence and mortality rates, economic and social factors such as agriculture and tourism are also considered [21]. It is possible to make more informed decisions about how resources should be allocated by taking a holistic approach to evaluating criteria [13].

It is also important to have a transparent and collaborative decision-making process for optimization. As part of this process, stakeholders are engaged throughout the decision-making process and all viewpoints are taken into consideration [17]. Decision-makers can ensure that decisions are made in a fair and equitable manner by engaging a diverse range of stakeholders, including public health officials, policymakers, and members of the public.

As well as identifying priority areas for vector-borne disease control, the best-worst multicriteria decision making method may also assist decision-makers in determining what the best-worst decision would be. Identifying areas of greatest impact for vector-borne diseases can be accomplished by systematically evaluating the impact of vector-borne diseases across different regions and criteria [51]. Therefore, public health and society will be able to reduce the burden of these diseases by ensuring that resources are directed towards where they are needed most.

Finally, optimizing the distribution of vector-borne diseases in India based on best-worst multicriteria decision-making methods has significant implications for optimization [52]. Public health officials and decision-makers can reduce the burden of these diseases on society and public health by applying a more comprehensive and collaborative approach to evaluating criteria and prioritizing interventions.

Theoretical implication

- In the case of vector-borne diseases in India, the use of the best-worst multicriteria decision-making method has important implications for optimization of the distribution of vector-borne diseases. In various fields such as finance, environmental management, and healthcare, multi-criteria decision analysis (MCDA) has been widely used. It may be possible to optimize public health decisions by using MCDA in the distribution of vector-borne diseases [12].
- To evaluate criteria in a systematic and objective manner, it is necessary to comply with one of the key theoretical implications. The traditional approach to making health decisions relies on subjective judgments and expert opinion, which can be biased and inconsistent. An objective and structured approach is provided by the best-worst method, in which criteria are systematically evaluated according to their relative significance. With this approach, public health decisions can be made more reliable and valid and bias can be reduced [37].
- It is also important to consider a more comprehensive and holistic approach to evaluating criteria as a further theoretical implication. In addition to public health factors, social and economic factors can also be evaluated using the best-worst method. In order to make more informed decisions concerning how to allocate resources, decision-makers can gain a deeper understanding of vector-borne diseases [35].
- The best-worst method can help identify trade-offs between different criteria, which is an important aspect of public health decision-making. Making informed decisions about how to allocate resources can be achieved by systematically evaluating the relative impacts of various criteria. Resource allocation can then be optimized to maximize overall impact while minimizing adverse trade-offs [32].
- The best-worst multicriteria decision-making approach is a useful tool for prioritizing the distribution of vector-borne diseases in India with its theoretical implications for optimization. To reduce the burden of these diseases on society and public health, decision-makers can evaluate criteria more objectively, systematically, and comprehensively [34].

Practical Implications

- A multicriteria decision-making method based on best-worst outcomes can contribute substantially to optimizing vector-borne disease distribution in India. Decision-makers can use this approach to improve public health outcomes by optimizing the allocation of resources. Vector-borne diseases have a significant impact on India's health, and more data and information are needed. To evaluate the relative impact of different criteria, the best-worst method relies on accurate and comprehensive data. Data on the prevalence, incidence, and social and economic impact of vector-borne diseases must be collected and analysed by decision-makers [6].
- Participation and engagement of stakeholders are also important practical implications. Based on the perspective of different stakeholders, the best-worst method evaluates criteria according to their relative impact. Therefore, stakeholders should be involved in decision-making processes and their perspectives should be considered when evaluating criteria. As well as helping decision-makers identify areas where resources are needed, the best-worst method can assist in determining which processes need to be improved. A systematic evaluation of different criteria can assist decision-makers in identifying interventions that will have the greatest impact and allocating resources accordingly. Public health outcomes can be improved by increasing the efficiency and effectiveness with which resources are used [53].
- Lastly, decision-makers can utilize the best-worst method to prioritize interventions based on the impact they are likely to have. A decision maker can identify interventions that will have the greatest impact on public health outcomes by evaluating the relative impact of different criteria. It is possible to use this information to assist decision-makers in targeting efforts on interventions that are most likely to be effective in reducing the burden of vector-borne diseases in India. To optimize vector-borne disease distribution in India, the best-worst multicriteria decision making method should be used. This approach can assist decision- makers in optimizing resource allocation and improve public health outcomes in India by providing valuable information regarding the impact of different criteria [54].

Conclusion

- Prioritizing vector-borne diseases based on the impact factor can be accomplished using the best-worst multicriteria decision- making method.
- Our research suggests, based on their impact on public health and the economy, that malaria, dengue fever, and chikungunya are the most important vector-borne diseases in India.
- The study also emphasizes the critical importance of taking social, economic, and environmental factors into account when evaluating the impact of vector-borne diseases in India.
- By applying a best-worst approach, decision-makers will be able to evaluate the relative impact of different criteria, resulting in a better allocation of resources and better public health outcomes.
- An important implication of utilizing the best-worst approach for optimizing vector-borne disease impacts in India is to collect more data, engage stakeholders, and prioritize interventions according to effectiveness.
- This study has theoretical implications regarding the use of multicriteria decision-making methods in public health, as well as potential applications to other health and environmental issues.
- Overall, our study provides valuable insights into the impact of vector-borne diseases in India and demonstrates the potential of the best-worst method to optimize resource allocation and improve public health outcomes.

limitations

- One limitation of our study is that the data used to evaluate the impact of vector-borne diseases in India may not be comprehensive or up to date, which could lead to inaccuracies in our findings.
- Another limitation of the best-worst method is that it relies on subjective judgments from stakeholders, which can introduce bias and variability into the decision-making process.
- Our study also focused solely on the impact of vector-borne diseases in India and may not be applicable to other regions or countries with different health and environmental contexts.
- The best-worst method is a relatively new approach to decision-making, and its effectiveness in optimizing the impact of vector- borne diseases in India has not yet been fully evaluated.
- We also acknowledge that our study did not consider the potential ethical implications of prioritizing certain diseases over others, and the potential impact of these decisions on vulnerable populations.
- The best-worst method is dependent on the criteria selected for evaluation, and it is possible that different criteria could lead to different prioritization outcomes.
- Finally, our study did not address the potential costs and resource requirements associated with implementing interventions to address vector-borne diseases, which could impact the feasibility and practicality of our proposed approach.

Future Search

The impact of vector-borne diseases in India through the best-worst multicriteria decision-making method should focus on addressing the limitations of our study and expanding the scope of analysis. One area for future research is to collect more comprehensive and up- to-date data on the impact of vector-borne diseases in India, which can improve the accuracy of the prioritization outcomes.

- future research should explore ways to mitigate bias and variability in the best-worst method, such as using statistical methods to weight criteria or incorporating multiple perspectives from stakeholders.
- Another area for future research is to expand the scope of analysis beyond vector-borne diseases and explore the potential of the best-worst method to optimize resource allocation and public health outcomes for other health and environmental issues. For example, the method could be applied to prioritize interventions for air pollution or waterborne diseases in India.
- future research should also explore the ethical implications of prioritizing certain diseases over others and the potential impact of these decisions on vulnerable populations. Research should also investigate the potential costs and resource requirements associated with implementing interventions to address vector-borne diseases in India, which can provide insight into the feasibility and practicality of our proposed approach.
- future research on optimizing the impact of vector-borne diseases in India through the best-worst multicriteria decision-making method has the potential to provide valuable insights into how to improve resource allocation and public health outcomes in India and can contribute to the development of more effective and efficient strategies for addressing health and environmental issues globally.

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