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Retraction

Retracted: "Best of Both World": The Amalgamation of Fuzzy Delphi Method with Nominal Group Technique for Dengue Risk Prioritisation Decision-Making

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] M. I. Ahmad Zamzuri, N. A. Naserrudin, N. K. M. Ali et al., ""Best of Both World": The Amalgamation of Fuzzy Delphi Method with Nominal Group Technique for Dengue Risk Prioritisation Decision-Making," *Journal of Function Spaces*, vol. 2022, Article ID 9581367, 8 pages, 2022.

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Research Article

"Best of Both World": The Amalgamation of Fuzzy Delphi Method with Nominal Group Technique for Dengue Risk Prioritisation Decision-Making

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Introduction. Dengue remains a public health threat. Clarifying the characteristics of future threats and prioritising intervention towards the highest risk potential can help to control and prevent dengue outbreaks. However, obtaining a consensus from panels of experts is certainly challenging due to the relative subjectivity of experience. Therefore, this article incorporates the fuzzy Delphi method (FDM) within a nominal group technique (NGT) as a multicriteria decision-making tool for (1) describing the characteristics of socioecological attributes (SEAs) with a high risk of causing dengue outbreak and (2) ranking those SEAs as priorities for intervention. *Material and Methods*. Experts were recruited using a purposive sampling technique. Informed consent was obtained before the start of the study. The NGT process began with an introductory presentation of dengue SEA by the moderator, followed by "silent generation." Next, each participant provided information in a round-robin fashion. Ideas were collected by the moderator and displayed publicly. All experts were given ample time and space to contribute and justify their ideas without interruption during the discussion step to yield agreeable SEA characteristics. Ultimately, FDM was incorporated in the voting step to ensure rigorous analysis. The study was approved by an ethical committee before its commencement. *Results*. A total of 10 field experts participated in the study, with a median experience of 7.5 years working on a dengue team. The common characteristics of SEA prone to cause dengue outbreaks were the presence of human-made containers, in high quantities, left unattended, and covered from direct sunlight. Apart from that, all eight SEAs passed the triangulation of fuzzy numbers and defuzzification processes. The average fuzzy numbers ranged between 0.500 and 0.780, and the threshold value (d) ranged from 0.055 to 0.196. Of the potential risk factors identified, experts ranked illegal dumping sites as the most important, followed by old and unused items and construction sites. *Conclusion*. The NGT process successfully helped to obtain a consensus among the expert panels in describing SEA characteristics. Nevertheless, the integration of FDM offered a robust analysis that validated their ranking in dengue risk prioritisation. Therefore, we strongly recommend the application of FDM to be incorporated in any public health decision-making process.

1. Introduction

Dengue fever remains a public health threat in many tropical and subtropical regions. Data from the World Health Organization estimates that nearly 390 million dengue infections occur every year, with increasing mortality globally [1]. Neither curative treatment nor an efficacious vaccine is currently available to stop rampant dengue infection. Therefore, vector control activities such as space spraying [2] and continuous surveillance and monitoring programs remain the primary prevention measures [3]. Since the dengue vector, the *Aedes* mosquito, breeds in water, control of potential breeding sites is the most effective way to prevent dengue outbreaks.

Literature has alluded to the significant impact of several factors on increasing dengue incidences: population growth, increasing population movement, rapid urbanization, environmental changes, and neglected rural areas and urban slums [4]. Earlier work at the present research setting in Seremban, Malaysia, corroborated those findings. Our exploratory phase yielded eight socioecological risk factors that contributed to the high incidence and outbreak occurrence of dengue in this setting: illegal dumping sites, illegal gardening, illegal human-made structures, damaged and abandoned vehicles, old and unused items, drainage system issues, construction sites, and abandoned houses. These attributes remain present, despite local literature showing that our population has sufficient knowledge about dengue prevention [5, 6]. The prevalence of these factors has caused tremendous challenges to vector control activities that are largely under the purview of the Malaysian Ministry of Health (MOH).

Despite the urgent need to both treat dengue cases and control the outbreaks, limited resources are available to invest in new technology for prevention measures, such as the *Wolbachia* program, which introduces a virus-competing bacteria to mosquitoes [7, 8]. Considering the public health urgency and the limited resources available to address the issue, interventions must be prioritised based on the known socioecological aetiology to ensure optimum resource utilisation for the maximum result. Thus, determining and setting risk priorities is fundamental to influence decision-making processes and subsequently communicate the evidence on the most cost-effective dengue control strategies [9].

Determining which methods are the most effective for eliciting priorities is crucial. Two of the most common methods found in medical and health studies are the nominal group technique (NGT) and the classical Delphi method [10]. The former is a structured, well-established, multistep, and facilitated group meeting technique. It offers the capability to generate and prioritise responses based on experts' technical expertise, and it allows participants to provide input without discrimination or hindrances to contribution.

The latter, the classical Delphi method, was developed in the 1950s by two scientists, Olaf Helmer and Norman Dalkey, particularly for defence research. It has been extensively applied in fields such as transportation, environment, social science, and technological research. However, some disadvantages of the method—such as ambiguity in the interpretation of experts' opinions or loss of experts' interest or data as a result of its time-consuming process—have led to additional costs to be borne by researchers [11, 12]. To overcome these weaknesses, this study attempted to modify and reconcile the classical Delphi method by using the fuzzy Delphi method (FDM).

FDM is a combination of the classical Delphi method and fuzzy set theory. Fuzzy set theory assumes that each set has a value from 0 to 1. Therefore, it employs triangulation statistics to measure the distance between levels of consensus among the expert panel [13]. As a result, FDM reduces the cost and time of outcome analysis, as well as enhances its completeness and consistency, because it can cater to the ambiguity and subjectivity of participant responses without jeopardising their original opinions [14]. Though its application in medical and related fields is scarce, it has potential for wide application in medical and health research [15–17].

Considering the need for effective prioritisation of dengue outbreak control strategies, our objectives were to (1) describe the characteristics of socioecological attributes (SEAs) with a high risk of causing dengue outbreaks and (2) rank those SEAs as priorities for intervention. To fulfil these objectives, we obtained expert opinion consensus through a combination of NGT and FDM analysis.

2. Methods

2.1. Samples. Ten local field experts participated in a face-to-face NGT+FDM meeting. The participants were selected by using purposive sampling, a nonprobabilistic sampling method, which is most appropriate in a semiquantitative study. An official letter was sent to the person in charge of the vector unit requesting a dedicated team to participate in the study according to our inclusion criteria. The chosen sample size was based on Jones and Twiss, who suggested using 10 to 50 experts [18]. A smaller sample size of 10 to 15 can be used when homogeneity exists among the experts [19]. We defined the sample as homogenous if they had been working in the field at least 20 days in a month for at least two consecutive years since 2019. This was very important to ensure that the participants had a detailed understanding of the current ecological dynamics in Seremban District. The primary inclusion criterion for selecting experts in this study was that they were currently serving in the vector-borne diseases unit of the Seremban District Health Office in Malaysia. Apart from that, we requested that participants had a good work record, were not subject to disciplinary action for the last two years, and were able to communicate and give good feedback in discussion. Importantly, due to the prolonged COVID-19 pandemic, some of the vector control teams had been deployed on a three-monthly basis to assist COVID-19 units. Therefore, those health personnel were excluded from the study. Additionally, the experts were selected based on their vast work experience in managing dengue outbreaks, with at least 1,000 hours in the field doing search and destroy activities, space spraying, residual spraying, health education activities, active and passive case

detection, entomological assessment, fogging activities, and legislative activities such as administering compounds.

These participants discussed the characteristics of eight SEAs with a high dengue outbreak risk to Seremban District. These attributes, obtained in the previous phase of our research, were illegal dumping sites, illegal gardening, illegal human-made structures, damaged and abandoned vehicles, old and unused items, drainage systems, construction sites, and abandoned houses.

2.2. Study Settings. The study was conducted in a meeting room that can accommodate up to 25 people at a time. This room is readily available at the vector unit of the Seremban District Health Office and is frequently used for multiagency planning purposes. A large projector screen allows good visual presentation, and four whiteboards allow note-taking and checklists to be displayed. The meeting room is also equipped with a personal stand-along microphone for each person, together with a good sound system that provides sufficient communication experiences. The availability of portable laptops has made data collection more user-friendly.

2.3. Steps of Nominal Group Technique (NGT) and Fuzzy Delphi Method (FDM). At the beginning of the study, the experts were given an introductory presentation by the moderator (the primary author) to guarantee that the objective of the study was explicitly stated. The NGT methodology follows four steps: silent generation, round-robin, clarification, and voting. We specifically used the NGT protocol used in health service research by McMillan et al. (2016) [20] for this study. FDM was introduced in the voting step and followed by a cognitive debriefing. We used the Malay language for NGT and FDM because it is the official language for the government sector and all of the participants were native speakers.

2.3.1. Step Zero: Introductory Session. This critical step sets a clear objective and mood for an NGT session. The moderator led the session by giving a 15-minute presentation that covered the epidemiology of dengue incidence and outbreaks in Seremban District. Additionally, risks for dengue transmission were briefed. The participants were given a thorough update of the results of the first phase of the research. All eight SEAs obtained in the previous study were conveyed to the participants. Finally, the objectives of the study and participants' role in NGT were clarified.

2.3.2. Step One: "Silent Generation." Around one hour was allocated for the silent generation step. Each attribute took between five and seven minutes to be completed, including a one-minute break before continuing to the next attribute. The experts were asked to write down or generate their own ideas, without discussion, about the criteria for each attribute, and to justify the severity level for each to increase the risk of dengue transmission. Specifically, the research statement given to the participants was "… describe in detail the characteristic of this attribute that will cause a higher risk for mosquito (Aedes sp.) breeding potential." The criteria for the possibility of an attribute to become a high risk for dengue depend on its potential to breed mosquitoes. The types of containers or objects that can hold water, the relative numbers of containers, their general conditions, and the surface environments of the attributes were the characteristics that needed to be described by the participants based on their experience in managing dengue outbreaks in the locality. They were free to write in point form or short description because this is a subjective experience that cannot be measured with a scale. They were provided with sheets of A4 paper and two blue ball-point pens for this session. This standardisation is a part of confidentiality to help to maintain the anonymity of the writer should there be any leakage of information after the session is completed.

2.3.3. Step Two: Round-Robin. During the round-robin step, each participant presented their criteria and justification without interruption by the others. Here, the moderator played a leadership role to ensure that every participant had an equal chance to express their opinion without being pressured by those with stronger personalities. Every participant was given the opportunity to present their findings in sequence, and they could add new ideas only in the next round. At this point, the researcher collated the data and tabulated them in Microsoft Excel. This was projected on a screen for all participants to see. Each attribute took roughly 15 to 20 minutes to achieve saturation (until everyone agreed no new ideas were to be shared); hence, this stage took around 2.5 hours to complete.

2.3.4. Step Three: Clarification. Unlike the previous step, the clarification process involved an open discussion among the participants. Any disagreements about the characteristics of SEA were handled during the clarification step. In essence, this step is aimed at harmonising and solidifying the information about the criteria.

2.3.5. Step Four: Voting. The application of FDM took place during the voting step to obtain the ranking of SEA, which was a primary objective of the study. Before commencement, the FDM technique was explained in detail to the participants. Specifically, they were instructed on how to score each item. Each of the eight attributes was scored using a 5-point Likert scale. We purposely chose a 5-point scale for two fundamental reasons: (1) it is simple to use [21] and easily comprehended because its centre value represents a moderate risk and (2) it can increase the response rate and quality and reduce participants' frustration level [22].

2.3.6. Additional Step: Cognitive Debriefing. Finally, cognitive debriefing was completed to solidify all the outcomes from the NGT+FDM session. Cognitive debriefing is just another name for the "discussion" step in our reference paper [20]. In particular, this is the last step in any discussion session; we hope every participant can reflect and conclude that the activities have been done collaboratively. It is also a gesture of professionalism in the government servant working environment. The study flow chart is shown in Figure 1, and it was conducted as suggested in the literature for a traditional nominal group technique [20].

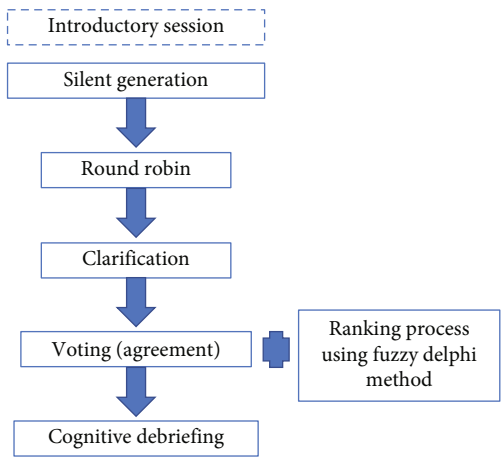

Figure 1: Study flow chart by incorporating the fuzzy Delphi method in nominal group technique. Modification based on work of McMillan et al. [20].

Table 1: Likert scale fuzzy numbers.

Likert scale	Linguistic variable	Triangular fuzzy number		
		n_1	n_2	n_3
1	Very minimal risk	0.0	0.0	0.2
2	Minimal risk	0.0	0.2	0.4
3	Moderate risk	0.2	0.4	0.6
4	High risk	0.4	0.6	0.8
5	Very high risk	0.6	0.8	0.1

Table 2: Characteristics of experts.

Expert	Job grade	Gender	Working experience (years)
1	U24	Male	30
2	U29	Male	11
3	H11	Male	10
4	U36	Male	19
5	U26	Male	30
6	H14	Male	4
7	U19	Male	3
8	U19	Male	5
9	H11	Male	3
10	U19	Male	3

2.4. Data Analysis for FDM. Our main motivation for using FDM to achieve consensus of risk priority was that it saves time and cost compared to the traditional Delphi method, which requires repeated cycles of discussion. Several integral elements must be considered when analysing FDM. First, the experts' Likert scale responses were converted into triangular fuzzy numbers. In general, traditional rating scales (e.g., 5- or 7-point Likert scales) measure human thinking by using crisp numbers [23]. With the complexity and uncertainty of human judgement, obtaining an accurate number for the purpose of evaluating it is extremely difficult. Hence, the fuzzy number is used to reduce the ambiguity of an expert's judgement, thus solving the limitation of the Likert scale. Table 1 demonstrates the conversion of the linguistic variable from the Likert scale into triangular fuzzy numbers.

Each Likert scale point was converted to three ratings: the minimum value (n_1), most reasonable value (n_2), and maximum value (n_3). For example, a rating of 5 would be transformed into fuzzy numbers of 0.6, 0.8, and 1.0, respectively.

Next, the fuzzy number scores were averaged and labelled m_1, m_2, and m_3 for further analysis to determine the threshold d-value. The value of m_1 is the average value of all n_1 obtained from all experts, while the values of m_2 and m_3 are derived from the average of all n_2 and n_3, respectively. For example, suppose all 10 experts rated an item X with a Likert scale score of 3 (moderate risk), so the value of m_1 is the average of all n_1 (0.2). Likewise, the value of m_2 is the average of all n_2 (0.4), and the value of m_3 is the average of all n_3 (0.6). The determination of the values m_1, m_2, and m_3 is essential because it is also vital for the acceptance of the item being measured. For an item to be accepted, it needed to attain a threshold d-value of ≤0.2. The d-value threshold was calculated using the formula that contains m_1, m_2, and m_3 values as below:

$$d(\bar{m}, \bar{n}) = \sqrt{\frac{1}{3}\left[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2\right]}. \quad (1)$$

Finally, a defuzzification process was conducted, which allowed for the determination of ranking (Amax score) and a value reflecting the degree of consensus of the participants (α-cut threshold ≥ 0.5). A higher Amax value indicates a higher ranking of the attribute compared to others. The calculation for the Amax value is

$$\text{Amax} = \frac{1}{4}(m_1 + m_2 + m_3). \quad (2)$$

2.5. Ethical Approval. This study was approved by the Universiti Kebangsaan Malaysia (UKM) Research Ethics Committee (UKM PPI/111/8/JEP-2019-854) and the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (NMRR-19-3909-51875). Nevertheless, the approval for publication was obtained from the National Medical Research Register of Malaysia (NIH.800-4/4/1 Jld. 104 (26)). The experts' informed consent was obtained prior to participation in this study.

3. Results

3.1. Characteristic of Respondents. A total number of 10 experts were recruited for this study. Each of them has significant experience in managing dengue outbreaks in the Seremban District of Malaysia, as demonstrated by their number of years working in this field. Table 2 details the characteristics of the experts involved in the study. All experts were male, at various levels of pay grade, with a median working experience of 7.5 years (interquartile range of 3.5-17 years).

Table 3: Expert consensus of criteria for each risk attribute.

Attribute	Agreed-upon criteria for high-risk dengue transmission
Illegal dumping site	(i) Man-made garbage (ii) High volume/quantity of garbage (iii) Covered from direct sunlight
Illegal garden	(i) Unattended/abandoned more than 2 weeks (ii) Presence of illegal structures that can store water (iii) Has water storage tank/container
Illegal man-made structure	(i) Unattended/abandoned more than 2 weeks (ii) Presence of parts or items that can store water (iii) Covered from direct sunlight
Damaged and abandoned vehicles	(i) Abandoned more than 2 weeks (ii) Has structural damage to the body or roof (iii) Covered from direct sunlight (iv) Presence of garbage or items that can store water
Old and unused items	(i) Unkempt and not properly covered (ii) Abandoned more than 2 weeks (iii) Covered from direct sunlight
Drainage system	(i) Obstructed drains (ii) Presence of water collecting area (iii) Obstructed/malfunctioning gutter
Construction site	(i) Abandoned or not operated for more than 2 weeks (ii) Presence of structural defect (e.g., flooring or wall) that can hold water (iii) Inefficient disposing system
Abandoned house	(i) Not well maintained by the neighbourhood (ii) Presence of structural defect that can hold water (iii) Becomes illegal dumping site or hoarding area

3.2. Determining Features of Socioecological Attributes. The first outcome of NGT was to obtain a consensus among the participants regarding the features of SEA with the highest risk potential for dengue transmission. The criteria for each of these attributes are outlined in Table 3. This result was derived following the round-robin and clarification steps of NGT. Nearly all the participants provided the main characteristics of attributes for *Aedes* sp. mosquitoes to breed. Features such as the presence of many human-made containers, old and unused items left unattended, and containers covered from direct sunlight were top and agreed by consensus.

3.3. Prioritisation of Socioecological Attributes. Figure 2 uses a spider diagram to represent the analysis of the participants' judgements using FDM to rank the attributes. All attributes obtained the threshold value (d-value) of ≤0.2, with a total d-construct of 0.162; thus, they were not subject to attribute deletion or removal. Furthermore, the α-cut threshold for all the attributes was more than 0.5, suggesting that consensus was obtained for all the attributes under study. The ranking of the attributes was calculated using the average fuzzy number (Amax value) during the defuzzification process. Detailed results are shown in Table 4.

4. Discussion

This article demonstrates that NGT and FDM provide a reliable method for assessing decision-making objectives. A combination of NGT and FDM was used to obtain expert consensus and ranking of the criteria and risk level of socioecological dengue receptivity attributes. By combining these powerful validation techniques, researchers have managed the best of both worlds. The first steps of NGT allowed all experts to freely put forth their ideas about the study without any external interference [24, 25], allowing the richness of data from different perspectives to separate from the homogeneity of their field experience and years of work. This exploratory capability in a structured process is one of the strengths of NGT [26].

To the best of our knowledge, this study is possibly the first to utilise FDM in dengue risk prioritisation decision-making, although its application has been well established for developing modules, models, frameworks, policies, and strategic planning for other types of organizations [27, 28]. FDM efficaciously integrates comprehensive statistical methods in decision-making processes and is compatible with other research methods, such as the conventional voting method of NGT. The flexibility to employ statistical analytic tools lowers the risk of group pressure for conformity significantly. Thus, the consensus reached is less biased.

Based on the NGT session and FDM analysis of expert opinions, ineffective solid waste management in the form of illegal dumping is the primary risk factor for the *Aedes* mosquito, the dengue vector, to breed and thus propagate dengue transmission. The illegal dumping site as a potential source for dengue outbreaks is not a new concept, and it was supported by a local spatial study with a similar setting [29]. Aminah et al. demonstrated dengue risk transmission among residences around an illegal dumping site by using

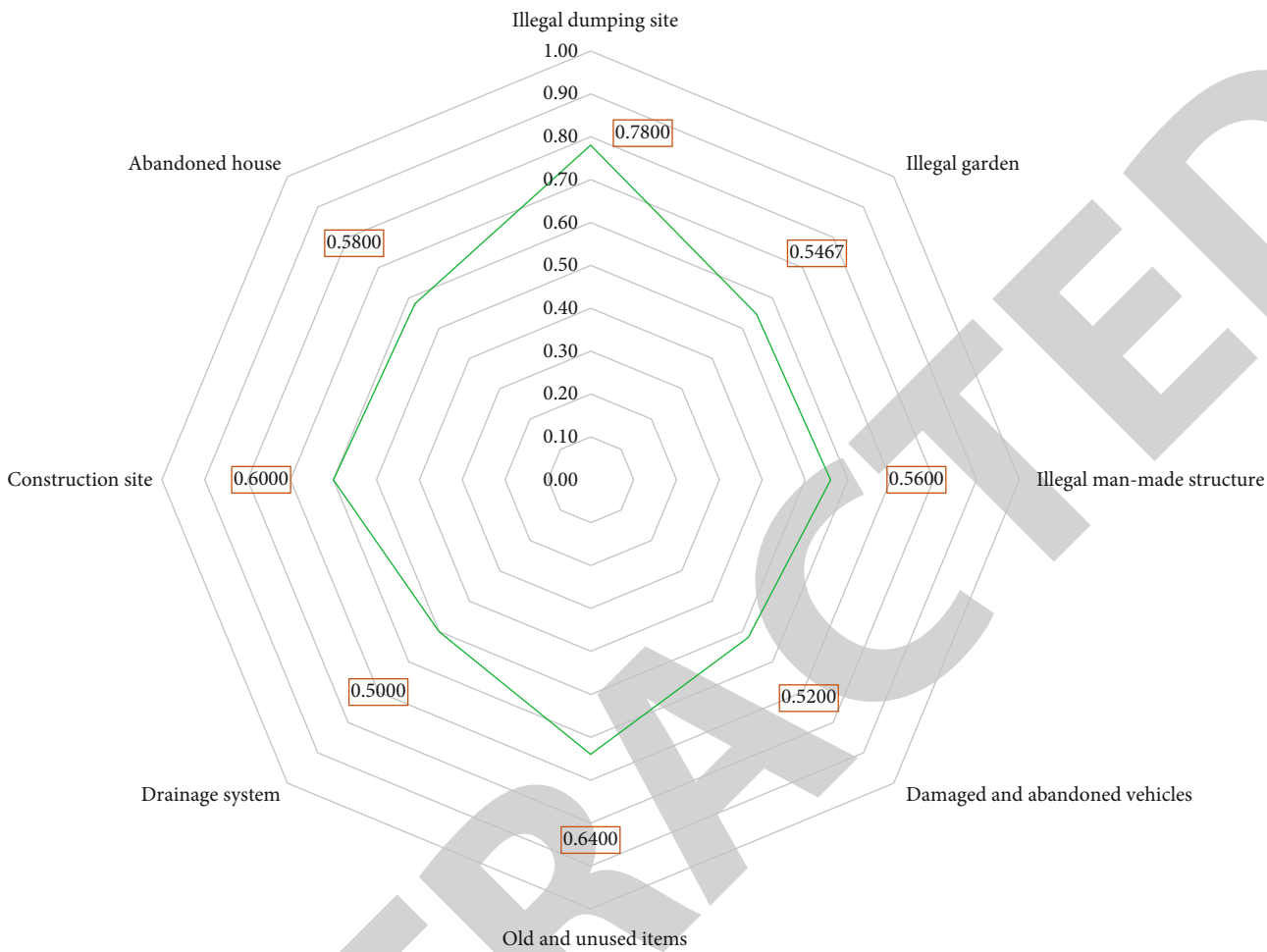

Figure 2: Spider diagram representing expert analysis of risk factors.

Table 4: Fuzzy Delphi result (ranking of socioecological attributes).

Attribute	Threshold value	FE	m_1, m_2, m_3 score	(Amax score)	Ranking
Illegal dumping site	0.055	7.800	0.580, 0.780, 0.980	0.780	1
Illegal garden	0.163	5.467	0.340, 0.560, 0.740	0.547	6
Illegal man-made structure	0.196	5.600	0.360, 0.560, 0.760	0.560	5
Damaged and abandoned vehicles	0.183	5.200	0.320, 0.530, 0.720	0.520	7
Old and unused items	0.196	6.400	0.440, 0.640, 0.840	0.640	2
Drainage system	0.153	5.000	0.300, 0.500, 0.700	0.500	8
Construction site	0.183	6.000	0.400, 0.600, 0.800	0.600	3
Abandoned house	0.165	5.8000	0.380, 0.580, 0.780	0.580	4

spatial modelling. Therefore, an improvement in solid waste management would likely have a profound effect on reducing the risk of dengue transmission [30].

Improper disposal of old and unused items such as tyres, cans, and plastic containers was determined by experts to be the second most important risk factor for dengue outbreaks. These items have the potential to hold water following rain, becoming breeding sites for the *Aedes* mosquito [31, 32]. Inactive or abandoned construction sites were ranked third because large water puddles resulting from incomplete construction or structural defects can become massive breeding sites [33]. Furthermore, the literature has reported an increase in odds (OR 3.3–17.4) of dengue clusters at construction sites, compared to other areas without them [34].

The remaining SEAs still have the potential to propagate dengue transmission, despite their lower ranking. The remaining risk factors have all been documented as places where containers such as buckets, drums, pots, bottles, and cans can store water [35, 36]. They were ranked in the following order: the presence of abandoned houses, illegal human-made structures, illegal gardens, damaged and abandoned vehicles, and obstructed drainage systems. An

obstructed drainage system can cause an increase in dengue incidences because stagnant water is the most suitable habitat for *Aedes* to breed [37, 38].

4.1. Strengths and Limitations. One major strength of this study was that it was completed, with an expert agreement reached, in a relatively short period by using FDM rather than the classical Delphi method. Additionally, the FDM mathematical analysis enabled this research to bridge the gap between the Likert scale's limitation of ambiguous meaning and its intervals. Furthermore, the structured methodology of NGT prevented the domination of certain experts who may be more opinionated than others. Such occasions can happen, for example, when a panel or focus group includes a senior member who is known to be dominant or have a strong personality, thus persuading other panellists in their opinions.

Despite the strengths, one limitation observed with this method is that the moderator conducting the NGT+FDM session needs basic topical experience in the field. As experienced in this study, significant time was spent on explanation with examples to ensure clear communication and successful results. Therefore, it would be most beneficial if the moderator is an expert with work experience in the subject. Additionally, a contemporary 7-point Likert scale was not used in this study. The 7-point scale can have a better effect because it helps to increase the accuracy and scale precision of the data obtained [14].

4.2. Recommendation. The strengths of this study methods guide our recommendation that analytical techniques such as NGT and FDM should be widely used in medical and health research in which expert opinion and consensus are needed. As such, FDM can facilitate and eventually solidify the experts' consensus in developing best practice protocols, which can serve as a standard reference in a local or national setting. Although limited, it is hoped that this study can offer a guide for future medical or health research that plans to incorporate FDM in the analysis.

5. Conclusion

The combination of NGT and FDM to reach expert consensus is highly recommended because it enhances transparency and shortens the process. The robustness of the FDM analysis validated the ranking of the socioecological risk factors. As such, incorporating FDM into decision-making research and processes is highly recommended.

Data Availability

All data are strictly confidential and reserved for the study. Please contact the authors for data request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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