mathematics

MDPI

Article

A Hybrid Spherical Fuzzy MCDM Approach to Prioritize Governmental Intervention Strategies against the COVID-19 Pandemic: A Case Study from Vietnam

Phi-Hung Nguyen [1,2], Jung-Fa Tsai [1], Thanh-Tuan Dang [3], Ming-Hua Lin [4,*], Hong-Anh Pham [2] and Kim-Anh Nguyen [2]

1 Department of Business Management, National Taipei University of Technology, Taipei 10608, Taiwan; hungnp30@fe.edu.vn (P.-H.N.); jftsai@ntut.edu.tw (J.-F.T.)
2 Faculty of Business, FPT University, Hanoi 100000, Vietnam; anhpth5@fe.edu.vn (H.-A.P.); anhnkhs130024@fpt.edu.vn (K.-A.N.)
3 Department of Industrial Engineering and Management, National Kaohsiung University of Science and Technology, Kaohsiung 80778, Taiwan; tuandang.ise@gmail.com
4 Department of Urban Industrial Management and Marketing, University of Taipei, Taipei 11153, Taiwan
* Correspondence: mhlin@utaipei.edu.tw

Abstract: The unprecedented coronavirus pandemic (COVID-19) is fluctuating worldwide. Since the COVID-19 epidemic has a negative impact on all countries and has become a significant threat, it is necessary to determine the most effective strategy for governments by considering a variety of criteria; however, few studies in the literature can assist governments in this topic. Selective governmental intervention during the COVID-19 outbreak is considered a Multi-Criteria Decision-Making (MCDM) problem under a vague and uncertain environment when governments and medical communities adjust their priorities in response to rising issues and the efficacy of interventions applied in various nations. In this study, a novel hybrid Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) and Fuzzy Weighted Aggregated Sum Product Assessment (WASPAS-F) model is proposed to help stakeholders such as governors and policymakers to prioritize governmental interventions for dealing with the COVID-19 outbreak. The SF-AHP is implemented to measure the significance of the criteria, while the WASPAS-F approach is deployed to rank intervention alternatives. An empirical case study is conducted in Vietnam. From the SF-AHP findings, the criteria of "effectiveness in preventing the spread of COVID-19", "ease of implementation", and "high acceptability to citizens" were recognized as the most important criteria. As for the ranking of strategies, "vaccinations", "enhanced control of the country's health resources", "common health testing", "formation of an emergency response team", and "quarantining patients and those suspected of infection" are the top five strategies. Aside from that, the robustness of the approach was tested by performing a comparative analysis. The results illustrate that the applied methods reach the general best strategy rankings. The applied methodology and its analysis will provide insight to authorities for fighting against the severe pandemic in the long run. It may aid in solving many complicated challenges in government strategy selection and assessment. It is also a flexible design model for considering the evaluation criteria. Finally, this research provides valuable guidance for policymakers in other nations.

Keywords: MCDM; COVID-19; governmental intervention strategies; spherical fuzzy analytic hierarchy process (SF-AHP); fuzzy weighted aggregated sum product assessment (WASPAS-F); Vietnam

check for updates

Citation: Nguyen, P.-H.; Tsai, J.-F.; Dang, T.-T.; Lin, M.-H.; Pham, H.-A.; Nguyen, K.-A. A Hybrid Spherical Fuzzy MCDM Approach to Prioritize Governmental Intervention Strategies against the COVID-19 Pandemic: A Case Study from Vietnam. *Mathematics* **2021**, *9*, 2626. https://doi.org/10.3390/math9202626

Academic Editors: Zhen-Song Chen, Witold Pedrycz, Lesheng Jin, Rosa M. Rodriguez and Luis Martínez López

Received: 8 September 2021
Accepted: 14 October 2021
Published: 18 October 2021

1. Introduction

As a result of its emergence, the World Health Organization (WHO) formally designated COVID-19 as a pandemic in March 2020 [1]. Global economic activities are in jeopardy as a consequence of the COVID-19 outbreak. Additionally, thousands of people have lost employment, the value of businesses has decreased, and many service providers have been forced to cease [2,3]. Initially, Vietnam was ranked among the most prosperous nations in controlling COVID-19 since the beginning of the outbreak. Due to the unavailability of appropriate therapies during this period, a number of solid interventions were implemented, such as the use of lockdown and travel bans in addition to school and workplace closures. In addition, many instructions including in-depth public health interference were issued, such as the use of facemasks, handwashing, and cleaning surfaces [4–8]. However, the present pandemic situation in Vietnam is even worse. According to the Centers for Disease Control and Prevention (CDC) [9], Vietnam has experienced 348,059 cases since the outbreak began, ranking 68 out of 222 countries and territories, while the frequency of cases per million people is 169 out of 222 nations and territories (On average, 3540 cases occur for every million individuals) [10] (https://ncov.moh.gov.vn/ (accessed on 1 September 2021). Indeed, the CDC reported that genetic variations of SARS-CoV-2 were developing and spreading worldwide. The Delta version of the virus causes COVID-19 to generate more infections and spread quicker than earlier variants. In unvaccinated persons, it may cause more severe disease than earlier strains [11]. Figure 1 presents the distribution of provinces with confirmed cases in Vietnam. Most of the confirmed cases were detected in the southern localities.

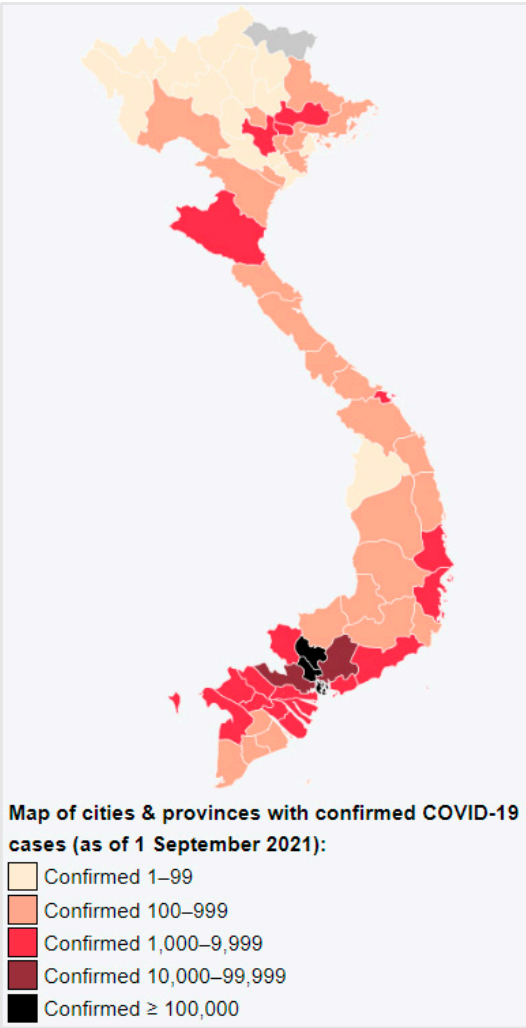

Figure 1. Maps of cities and provinces with confirmed COVID-19 cases in Vietnam.

For that reason, governments have taken many steps to curb the spread of COVID-19, which exerted a harmful influence on their local economies [12,13]. Gatherings in public places, schools, and workplaces, for example, are strongly discouraged [14]. That aside, Mardani et al. [15] mentioned the roles of the information management systems as a type of digital health intervention during the COVID-19 pandemic. Meanwhile, Golinelli et al. [16] reviewed the adoption of digital technologies (DTs) in healthcare during the pandemic. They indicated that DTs play a critical function in mitigating the adverse effects of COVID-19 on human health. Especially in the education sector, many higher education institutions used DTs as a practical approach to resume suspended semesters and control the spread of COVID-19. Therefore, nowadays, DT interventions have a significant impact on the healthcare sector [17,18], educational field [19,20], communications [21,22], finance and banking [23], and so on.

Numerous governments have enforced nationwide lockdowns and advised residents to maintain social isolation or self-quarantine. Controlling the disease's quick spread is critical, as the number of affected persons continues to rise alarmingly, particularly in nations such as Italy, Hong Kong, Brazil, and Korea, where circumstances threaten to spiral out of control [24–27]. Now, the COVID-19 virus has spread almost everywhere, and most of the planet is in lockdown mode. It is often regarded as the most severe catastrophe since the last World War [28,29]. However, previous research has ignored the impact of factors affecting COVID-19 preventative measures. In fact, the solutions employed thus far are insufficient to address the COVID-19 issue, as several examples of individuals encountering serious challenges of various types have occurred. All nations require a more thorough and robust plan of action that considers the multiple criteria affected during a pandemic [30].

Multi-Criteria Decision-Making (MCDM) methods have been widely employed in various fields [31–33]. However, they are rarely utilized in evaluating government interventions and measures against COVID-19. MCDM challenges are plagued by imprecision and uncertainty. To handle and measure imprecision and vagueness, the fuzzy MCDM uses fuzzy numbers [34]. There are no concrete answers to real-life decision-making challenges since human beings think instinctively. Because of the need to deal with ambiguity in real-life problems, numerous approaches and theories have been developed to deal with this [35]. The evaluation of government solutions entails several conflicting criteria, including cost reduction, ease of implementation, and success in limiting the spread of COVID-19, all of which must be balanced using multi-criteria decision-making approaches. As a result, MCDM methodologies can be successfully employed to help governments determine the optimum plan [36]. It is evident that a better understanding of strategies is required to combat the pandemic. On the other hand, MCDM is a suitable tool to help decision makers identify priority strategies for developing comprehensive disaster preparedness and responses [37]. Considering all of these points, the authors reviewed the potential applications of quantitative and qualitative methods in intervention strategies for the global pandemic.

The availability of data determines the uncertainty model. The statistics on the COVID-19 pandemic are based on the expertise of specialists during a brief period. Stochastic modeling may be used if there are enough observations [36]. While decision makers express their opinions as a crisp value in the classical MCDM technique, when ambiguous and vague information is included in decision making, these crisp values are frequently insufficient to solve real-world decision-making difficulties. Therefore, fuzzy set theory has been applied to handle vagueness and complexity [38]. The recent extensions of Spherical Fuzzy sets comprise the membership, non-membership, and hesitancy degrees, which aim to enlarge the domain area for the assignment of these uncertain degrees [39]. Consequently, given the freedom to choose the degree of power, we prefer the Spherical Fuzzy set. The purpose of this study is to propose a Spherical Fuzzy MCDM approach for managing unclear and imprecise information more effectively.

To the authors' best knowledge, only a few studies were found to evaluate and rank the governmental interventions for the COVID-19 outbreak in general, particularly by using the Fuzzy MCDM models. Furthermore, this study is the first to deploy a novel hybrid Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) and Fuzzy Weighted Aggregated

Sum Product Assessment (WASPAS-F) approach to analyze the intervention strategies used to halt the spread of the COVID-19 pandemic in emerging nations, particularly in Vietnam.

Therefore, the contribution of this study to the existing literature is to develop a decision support model for the evaluations of governmental intervention strategies against the COVID-19 pandemic. In the proposed model, the originalities of our study are as follows:

(1) This study aims to present an overview of the intervention practices applied in various countries. It is well known that there are few studies in the literature examining government plans for COVID-19's spread using the MCDM method. Due to this dearth in the literature, this study's primary motivation is to evaluate governments' strategies for the COVID-19 pandemic, which is currently a major threat to all countries worldwide.
(2) This study is the first to utilize a novel hybrid SF-AHP and WASPAS-F model to investigate the optimal intervention strategies used to deal with the spread of the COVID-19 pandemic in emerging nations, particularly in Vietnam.
(3) This study provides five potential criteria based on the relevant literature research and expert consultations, including "total anticipated cost", "ease of implementation", "high acceptance among citizens", "effectiveness in reducing the spread of COVID-19", and "irreplaceability by other measures". It then prioritizes the relative weights of the proposed criteria using SF-AHP. Finally, the WASPAS- F technique is deployed to rank 15 government intervention strategies for the COVID-19 pandemic by comprehensively reviewing existing government protection practices.

The rest of this research is structured as follows. A complete literature review of MCDM is detailed in the next section. The methodology used to determine the weights and rankings of the strategies is discussed in Section 3. An empirical case study is provided, and the results are derived in Section 4. In Section 5, a comparative analysis is carried out. Sections 6 and 7 contain the result discussions, conclusions, and implications.

2. Literature Review

This section is about the literature review on MCDM techniques, the existing intervention strategies used in various nations worldwide, and the criteria influencing selecting and applying governmental intervention practices.

2.1. Literature Review on MCDM Methods

It is necessary to develop decision-making tools and techniques capable of dealing with such complexity. Individuals or groups of decision makers can use MCDM approaches to make suitable and transparent judgments in difficult situations. This aids in evaluating and selecting the best alternative based on a set of criteria [40]. It is applied in a wide range of areas, including the social sciences [41,42], engineering [43,44], economics [45,46], health care [47,48], and renewable energy [49–51]. Tsai et al. [52] emphasized the importance of combining MCDM techniques to investigate decision issues, since the outcomes obtained by several MCDM techniques are more trustworthy than those determined by a single MCDM approach. Among various MCDM models existing in the literature, the Analytic Hierarchy Process (AHP) proposed by Saaty [53] has been widespread and developed with fuzzy logic to overcome vagueness in making decisions [54–56].

The COVID-19 pandemic has had various consequences, including economic, social, and psychological consequences, in addition to a substantial and widespread influence on global health, prompting academics to conduct additional research on this phenomenon. The rapid development of the COVID-19 outbreak has caused countries to implement a variety of tactics, including directing the implementation of numerous measures [36]. Due to the COVID-19 pandemic, which has a negative impact on all countries and has become a significant threat, it is necessary to determine the most effective strategy for governments by considering a variety of criteria. However, few studies in the literature can assist governments in this topic. In the context of COVID-19 prevention practices, Chen [57] utilized an integrating FAHP and the fuzzy technique for order preference by similarity to the ideal solution (FTOPSIS) approach to investigate appropriate occupational healthcare interventions for a company during the COVID-19 pandemic. Additionally, Wu et al. [58] mentioned a set of COVID-19 intervention strategies adopted by numerous countries.

Similarly, Samanlioglu et al. [5] conducted a hesitant F-AHP model to evaluate governmental interventions. Furthermore, Pinto Neto et al. [24] studied some practices against the transmission dynamics of COVID-19 in Brazil. As mentioned in the healthcare system, Mardani et al. [15] proposed a hybrid MCDM approach to identify the significant challenges of COVID-19 interventions in light of the digital era. Alkan and Kahraman [44] proposed the q-rung orthopair Fuzzy TOPSIS approach to evaluate government strategies against the COVID-19 pandemic. In this study, the strategies applied by the governments and the criteria that affected these strategies were determined to be seven alternatives and eight criteria. Their results highlighted a quarantine and strict isolation strategy as the best strategy to prevent the spread of COVID-19. However, various intervention strategies have been proposed in the world thus far. Therefore, this study will comprehensively investigate the optimal strategies by adding more current governmental strategies toward the COVID-19 outbreak in Vietnam.

On Spherical Fuzzy sets combined with various MCDM models, Kutlu Gündoğdu and Kahraman [59] used SF-AHP to select an industrial robot. Yildiz et al. [60] offered the SF-AHP model to assess career management activities contributing to millennial employee retention. Nasir et al. [61] introduced the concepts of Complex T-Spherical Fuzzy Relations in the financial sector. According to the study of Duleba et al. [62], the Interval-Valued Spherical Fuzzy AHP technique was employed to analyze public transportation development in a Turkish city.

Even with a variety of integrated Spherical Fuzzy sets and MCDM models to deal with the real-world problems mentioned above, there is no study taking advantage of applications that are a combination of the SF-AHP and WASPAS-F approaches to rank and prioritize a set of intervention strategies which various governments have applied to handle with COVID-19 pandemic. The set of governmental intervention responses will be presented in the next part of this study.

2.2. Literature Review on Governmental Intervention Strategies

It is evident that there is a limited number of studies conducted mentioning the context of evaluating intervention strategies under infectious disease outbreaks. After reviewing the current literature, the potential intervention strategies can be summarized into a set of 15 practices that have been adopted in numerous nations as follows:

A1-External border restrictions: This practice is used in 211 countries and territories [63]. Influenza epidemics were delayed by 1 week and 2 months, respectively, due to international border restrictions. Restrictions on overseas movements postponed the expansion and their peak for periods, ranging from a few days to 4 months [64].

A2-Restriction of nonessential businesses: Although the WHO did not mention the restriction of nonessential businesses, this intervention was included in the nonpharmaceutical interventions to decrease the intensity of the pandemic by limiting person-to-person contact [65]. Porsse et al. [66] proved that the shutdown of non-essential businesses, plus the case count and mortality rate, causes a significant drop in Gross Domestic Product (GDP), even with support from government fiscal packages.

A3-Common health testing: Mass testing for COVID-19 aims to track persons with active cases who are asymptomatic or pre-symptomatic so that quarantine, as well as rapid identification and testing of close contacts, can halt the spread of the virus [67]. Mass antigen testing could be an effective tool for COVID-19 prevention, but for long-term effects, regular retesting would be required after investigating the effects of mass antigen testing on the pandemic, using data from a specially designed national testing program implemented in Slovakia in autumn of 2020 [68].

A4-Internal border restrictions: Internal border restrictions include government policies to reduce the ability to move freely within a country [5]. The priority of this intervention is to separate the unidentified cases from their community members. Internal border restrictions have been applied in 211 countries, including the USA, Malaysia, New Zealand, Philippine, UK, Schengen countries, and many others [63].

A5-Social distancing: This is considered to reduce interactions between people and hence reduce the transmission possibility from unidentified cases to others. This intervention is conducted based on the principle that people will be contaminated if they have physical interactions with a person with COVID-19 [69].

A6-Health monitoring: The WHO confirmed that measures to track and monitor public health are essential to limiting the transmission of COVID-19 and reducing deaths, and they issued a number of publications included guidance, reports, and research to provide suggestions for monitoring the public health during the pandemic [70,71].

A7-Quarantining patients and those suspected of infection: When the antiviral medications and effectiveness of vaccines were not active in the early stage of the pandemic, quarantine was suggested by governments as one of the non-pharmaceutical interventions with the hope of the transmission deduction [72]. However, this application has limited evidence for its effectiveness in research and studies and is based on historical and contemporary observations [73].

A8-Enhanced control of the country's health resources: Reallocation of acute care beds, the fast building of new hospitals, and generous assistance of health professionals in other less-severe locations are among the timely medical resources given which must be sufficient over time [74]. The previous study recommended maximizing the advantages of scarce resources, treating everyone equally, encouraging and rewarding instrumental value, and prioritizing the most vulnerable people [75,76].

A9-Curfew: The curfew measures were effective and efficient, but they must be strict nationwide, successfully preventing the spread of the disease. Dechsupa et al. [77] verified that the number of new COVID-19 cases declined following the curfew. While the epidemic is still growing, curfews have significantly slowed it down, especially for the most vulnerable people [78].

A10-Restrictions of mass gatherings: The WHO confirmed that poorly planned and managed mass gatherings pose serious public health risks and issued a set of critical recommendations for mass gatherings, including both public health authorities and organizers, to prevent the spread of COVID-19 [79].

A11-Declaration of emergency: Japan and the US have evaluated the impact of emergency declarations on different aspects and found essential changes in the behaviors and daily lives of people [80]. However, the direct impact on the pandemic was rarely mentioned. Yamamura et al. [81] indicated that the proclamation had a more significant impact on promoting preventative behaviors than it did on mental health.

A12-Closure of schools: School closures had been applied in the previous pandemic to decrease the wide spread of the virus [82]. In fact, nonpharmaceutical interventions to combat severe influenza outbreaks and pandemics include postponing school start times [83].

A13-Vaccinations: In the context of the global shortage of vaccines, the Vietnamese government has mobilized countries and international organizations in various ways to access vaccines for citizens. The government has actively negotiated the purchase of vaccines and, at the same time, directed the research and production of vaccines in the country [84]. Moreover, the government defines a vaccine strategy focusing on solutions such as urgent importing, research, technology transfer, domestic production of vaccines, and vaccination campaigns.

A14-Formation of an emergency response team: This strategy is defined as transforming part of the government's administrative capacity or creating new mission teams or offices to respond to the crisis. The previous study revised several government strategies, including resource mobilization and de-mobilization; new and adaptive solutions; modularization; bounded autonomy; the use and combination of available ideas, tools, and resources; and strategic polyvalence, which designs solutions to serve new purposes in a new situation [85,86].

A15-Restriction of nonessential government services: Concerning government policies that restrict nonessential government services and estimate the importance of unnecessary service restrictions during the pandemic, a literature review pointed out a lack of research in this field compared with other topics, which primarily concern non-pharmaceutical interventions and the medical field [5].

2.3. Literature Review on Proposed Criteria

Although several interventions have been extended to tackle the COVID-19 outbreak, they may be ineffective or unsuccessful. Samanlioglu et al. [6] directly compared the intervention strategies; however, they did not mention critical factors. Furthermore, Pinto Neto [24] also did not cover any related factors to determine the optimal strategy in Brazil. Another piece of research from Ghorui et al. [87] highlighted some significant risk factors of COVID-19, which slightly affected some protective strategies. It is clear from previous research that no study has been conducted on developing rigorous criteria for selecting and evaluating COVID-19 treatments and interventions. Based on the relevant literature research and experts' opinions, this study aims to identify the challenges and influencing criteria of COVID-19 interventions. Therefore, this study considered five potential criteria related to governmental intervention measures based on experts' opinions as follows: (C1) total estimated cost; (C2) ease of implementation; (C3) high acceptability to citizens; (C4) effectiveness for preventing the spread of COVID-19; (C5) irreplaceability by other measures.

3. Materials and Methods

3.1. Research Framework

This paper proposes a novel integrated MCDM model for prioritizing governmental interventions regarding the five proposed criteria to tackle the COVID-19 outbreak. The proposed research framework consists of 2 phases, as illustrated in Figure 2. In Phase 1, the assignment of fuzzy weights to criteria based on pairwise comparisons is performed using the SF-AHP model. Language terms and Spherical Fuzzy numbers show how each alternative is rated and how each criterion is weighted. In Phase 2, the Fuzzy WASPAS model is used to rank all alternatives. As shown in the picture, the fuzzy decision-making approach for the governmental intervention strategy evaluation and prioritization undergoes a comparative analysis to assess its robustness and comprehensiveness.

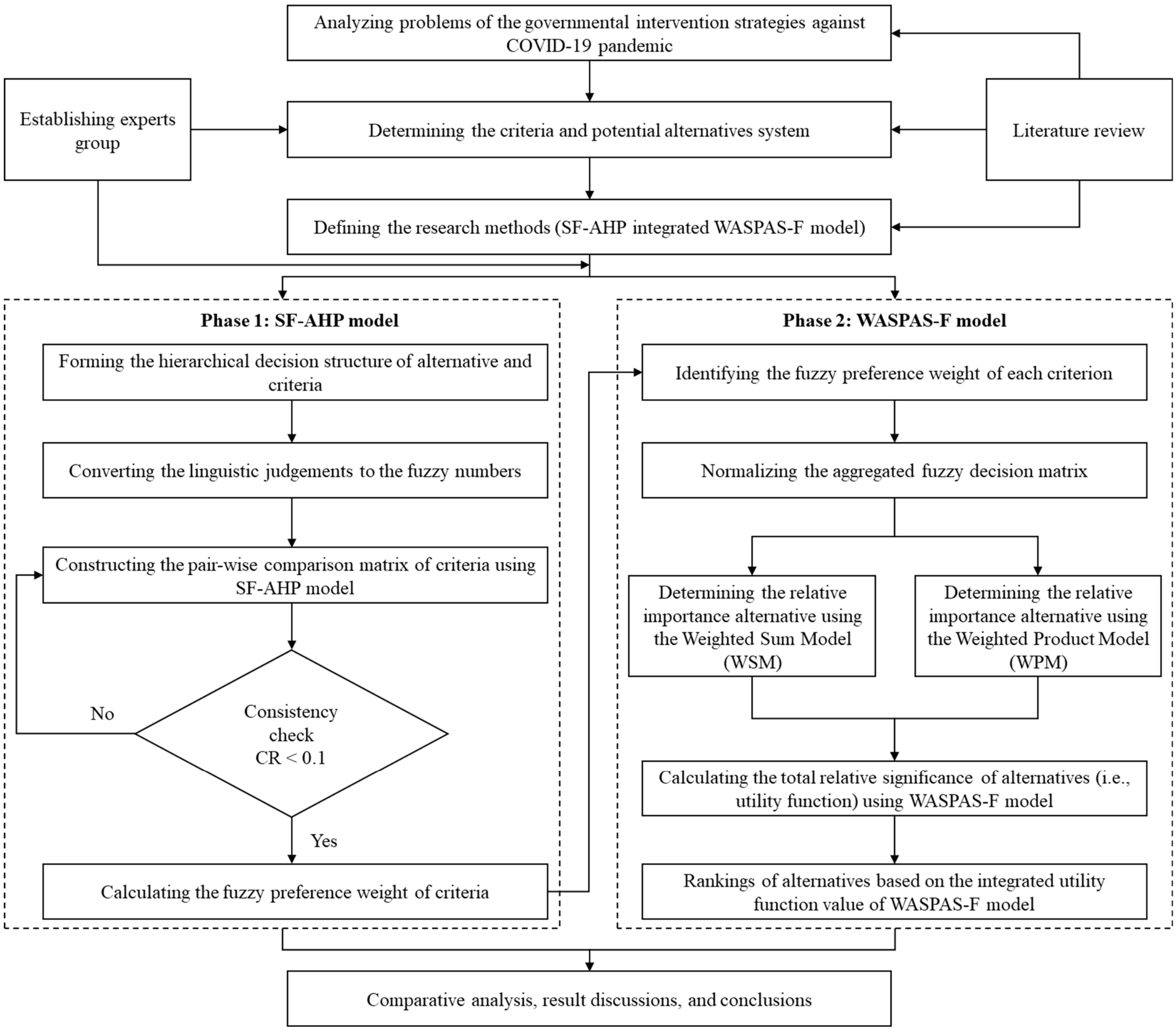

Figure 2. The research framework of SF-AHP integrated into the WASPAS-F model.

3.2. Spherical Fuzzy Analytical Hierarchy Process (SF-AHP)

Kutlu Gündouğdu and Kahraman [88] developed Spherical Fuzzy Sets (SFS). The SF values comprise the membership, non-membership, and hesitancy degrees to present the uncertainty, satisfying the following condition. Figure 3 indicates the geometric representations of the SFS in the 3D plane. The differences among the intuitionistic fuzzy set, Pythagorean fuzzy set, neutrosophic set, and Spherical Fuzzy sets are clearly demonstrated.

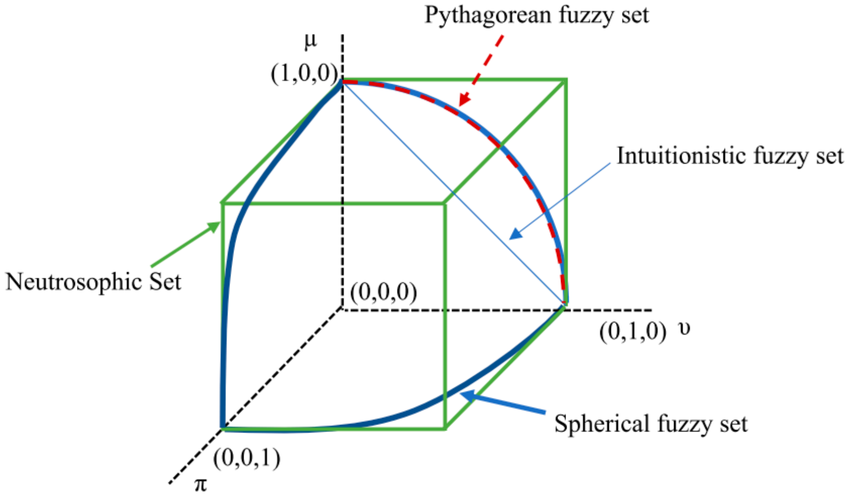

Figure 3. Geometric representations of SFS in a 3D plane.

Definition 1. *SFS $\widetilde{A}_S$ is denoted as follows:*

$$\widetilde{A}_S = \{x, (\mu_{\widetilde{A}_S}(x),\ v_{\widetilde{A}_S}(x),\ \pi_{\widetilde{A}_S}(x))\big| x \in X\} \quad (1)$$

where $\widetilde{A}_S$ denotes a spherical fuzzy set of the universe X:

$$\mu_{\widetilde{A}_S}(x):\ X \to [0,1], v_{\widetilde{A}_S}(x) : X \to [0,1], \pi_{\widetilde{A}_S}(x) : X \to [0,1] \quad (2)$$

and

$$0 \le \mu^2_{\widetilde{A}_S}(x) + v^2_{\widetilde{A}_S}(x) + \pi^2_{\widetilde{A}_S}(x) \le 1 \quad (3)$$

where $\forall x \in X$, and for each x, $\mu_{\widetilde{A}_S}(x)$, $v_{\widetilde{A}_S}(x)$, and $\pi_{\widetilde{A}_S}(x)$ denote the membership, non-membership, and hesitancy levels of x to $\widetilde{A}_S$, respectively.

Definition 2. *Let $\widetilde{A}_S = (\mu_{\widetilde{A}_S},\ v_{\widetilde{A}_S},\ \pi_{\widetilde{A}_S})$ and $\widetilde{B}_S = (\mu_{\widetilde{B}_S},\ v_{\widetilde{B}_S},\ \pi_{\widetilde{B}_S})$ be two SFS. Some arithmetic operations of SFS are presented as follows:*

- *Union:*

$$\begin{aligned}\widetilde{A}_S \cup \widetilde{B}_S \ &= \{max\ \{\mu_{\widetilde{A}_S},\ \mu_{\widetilde{B}_S}\}, min\ \{v_{\widetilde{A}_S},\ v_{\widetilde{B}_S}\},\ min\{(1 \\ &\quad -((max\ \{\mu_{\widetilde{A}_S},\ \mu_{\widetilde{B}_S}\})^2 \\ &\quad +(min\{v_{\widetilde{A}_S},\ v_{\widetilde{B}_S}\})^2))^{1/2},\ max\ \{\ \pi_{\widetilde{A}_S},\ \pi_{\widetilde{B}_S}\}\}\}\end{aligned} \quad (4)$$

- *Intersection:*

$$\begin{aligned}\widetilde{A}_S \cap \widetilde{B}_S \ &= \{min\ \{\mu_{\widetilde{A}_S},\ \mu_{\widetilde{B}_S}\}, max\ \{v_{\widetilde{A}_S},\ v_{\widetilde{B}_S}\},\ max\{(1 \\ &\quad -((min\ \{\mu_{\widetilde{A}_S},\ \mu_{\widetilde{B}_S}\})^2 \\ &\quad +(max\{v_{\widetilde{A}_S},\ v_{\widetilde{B}_S}\})^2))^{1/2},\ min\ \{\ \pi_{\widetilde{A}_S},\ \pi_{\widetilde{B}_S}\}\}\}\end{aligned} \quad (5)$$

- *Addition:*

$$\widetilde{A}_S \oplus \widetilde{B}_S = \{(\mu^2_{\widetilde{A}_S} + \mu^2_{\widetilde{B}_S} - \mu^2_{\widetilde{A}_S}\mu^2_{\widetilde{B}_S})^{1/2},\ v_{\widetilde{A}_S}v_{\widetilde{B}_S}, ((1-\mu^2_{\widetilde{B}_S})\pi^2_{\widetilde{A}_S} + (1-\mu^2_{\widetilde{A}_S})\pi^2_{\widetilde{B}_S} - \pi^2_{\widetilde{A}_S}\pi^2_{\widetilde{B}_S})^{1/2}\} \quad (6)$$

- *Multiplication:*

$$\widetilde{A}_S \otimes \widetilde{B}_S = \{\mu^2_{\widetilde{A}_S}\mu^2_{\widetilde{B}_S}, (v^2_{\widetilde{A}_S} + v^2_{\widetilde{B}_S} - v^2_{\widetilde{A}_S}v^2_{\widetilde{B}_S})^{1/2}, ((1-v^2_{\widetilde{B}_S})\pi^2_{\widetilde{A}_S} + (1-v^2_{\widetilde{A}_S})\ \pi^2_{\widetilde{B}_S} - \pi^2_{\widetilde{A}_S}\pi^2_{\widetilde{B}_S})^{1/2}\} \quad (7)$$

- *Multiplication by a scalar;* $\lambda > 0$:

$$\lambda \,.\, \widetilde{A}_S = \{(1-(1-\mu^2_{\widetilde{A}_S})^{\lambda})^{1/2},\ v^{\lambda}_{\widetilde{A}_S},\ ((1-\mu^2_{\widetilde{A}_S})^{\lambda}-(1-\mu^2_{\widetilde{A}_S}-\pi^2_{\widetilde{A}_S})^{\lambda})^{1/2}\} \tag{8}$$

- *Power of* $\widetilde{A}_S$; $\lambda > 0$:

$$\widetilde{A}_S^{\lambda} = \{\mu^{\lambda}_{\widetilde{A}_S},\ (1-(1-v^2_{\widetilde{A}_S})^{\lambda})^{1/2},\ ((1-v^2_{\widetilde{A}_S})^{\lambda}-(1-v^2_{\widetilde{A}_S}-\pi^2_{\widetilde{A}_S})^{\lambda})^{1/2}\} \tag{9}$$

Definition 3. *For these SFS* $\widetilde{A}_S = (\mu_{\widetilde{A}_S}, v_{\widetilde{A}_S}, \pi_{\widetilde{A}_S})$ *and* $\widetilde{B}_S = (\mu_{\widetilde{B}_S}, v_{\widetilde{B}_S}, \pi_{\widetilde{B}_S})$, *the following are valid under the condition* $\lambda,\ \lambda_1, \lambda_2 > 0$:

$$\widetilde{A}_S \oplus \widetilde{B}_S = \widetilde{B}_S \oplus \widetilde{A}_S \tag{10}$$

$$\widetilde{A}_S \otimes \widetilde{B}_S = \widetilde{B}_S \otimes \widetilde{A}_S \tag{11}$$

$$\lambda(\widetilde{A}_S \oplus \widetilde{B}_S) = \lambda\widetilde{A}_S \oplus \lambda\widetilde{B}_S \tag{12}$$

$$\lambda_1\widetilde{A}_S \oplus \lambda_2\widetilde{A}_S = (\lambda_1+\lambda_2)\,\widetilde{A}_S \tag{13}$$

$$(\widetilde{A}_S \otimes \widetilde{B}_S)^{\lambda} = \widetilde{A}_S^{\lambda} \otimes \widetilde{B}_S^{\lambda} \tag{14}$$

$$\widetilde{A}_S^{\lambda_1} \otimes \widetilde{A}_S^{\lambda_2} = \widetilde{A}_S^{\lambda_1+\lambda_2} \tag{15}$$

Definition 4. *For the Spherical Weighted Arithmetic Mean (SWAM) concerning* $w = (w_1, w_2, \ldots, w_n)$; $w_i \in [0,1]$; $\sum_{i=1}^{n} w_i = 1$, the SWAM is defined as follows:

$$SWAM_w(\widetilde{A}_{S1}, \ldots, \widetilde{A}_{Sn}) = w_1\widetilde{A}_{S1} + w_2\widetilde{A}_{S2} + \ldots + w_n\widetilde{A}_{Sn} = \{[1-\prod_{i=1}^{n}(1-\mu^2_{\widetilde{A}_{Si}})^{w_i}]^{1/2}, \prod_{i=1}^{n} v^{w_i}_{\widetilde{A}_{Si}}, [\prod_{i=1}^{n}(1-\mu^2_{\widetilde{A}_{Si}})^{w_i} - \prod_{i=1}^{n}(1-\mu^2_{\widetilde{A}_{Si}}-\pi^2_{\widetilde{A}_{Si}})^{w_i}]^{1/2}\} \tag{16}$$

Definition 5. *For the Spherical Weighted Geometric Mean (SWGM) concerning* $w = (w_1, w_2 \ldots, w_n$; $w_i \in [0,1]$; $\sum_{i=1}^{n} w_i = 1$, *the SWGM is defined as follows:*

$$\begin{aligned} SWGM_w(\widetilde{A}_{S1}, \ldots, \ddot{A}_{Sn}) &= \widetilde{A}_{S1}^{w_1} + \widetilde{A}_{S2}^{w_2} + \ldots + \widetilde{A}_{Sn}^{w_n} \\ &= \prod_{i=1}^{n} \mu^{w_i}_{\widetilde{A}_{Si}},\ [1-\prod_{i=1}^{n}(1-v^2_{\widetilde{A}_{Si}})^{w_i}]^{1/2}, [\prod_{i=1}^{n}(1-v^2_{\widetilde{A}_{Si}})^{w_i} \\ &\quad -\prod_{i=1}^{n}(1-v^2_{\widetilde{A}_{Si}}-\pi^2_{\widetilde{A}_{Si}})^{w_i}]^{1/2} \end{aligned} \tag{17}$$

In this paper, SF-AHP was applied to identify the criteria weights of the governmental intervention strategies. The SF-AHP method has five steps, which are as follows.

Step 1: A hierarchical framework is divided into three levels, including the research goal (level 1), proposed criteria $C = \{C_1, C_2, \ldots C_n\}$ (level 2), and intervention alternatives $A = \{A_1, A_2, \ldots A_m\}$ (*within* $m \geq 2$).

Step 2: Pairwise comparison matrices are conducted regarding linguistic terms, as shown in Table 1. The score indices (SIs) are calculated by Equations (18) and (19):

$$SI = \sqrt{\left|100 * [(\mu_{\widetilde{A}_S} - \pi_{\widetilde{A}_S})^2 - (v_{\widetilde{A}_S} - \pi_{\widetilde{A}_S})^2]\right|} \tag{18}$$

Table 1. SF-AHP linguistic terms.

Definition	(μ, v, π)	Score Index (SI)
Absolutely more Importance (AMI)	(0.9, 0.1, 0.0)	9
Very High Importance (VHI)	(0.8, 0.2, 0.1)	7
High Importance (HI)	(0.7, 0.3, 0.2)	5
Slightly More Importance (SMI)	(0.6, 0.4, 0.3)	3
Equally Importance (EI)	(0.5, 0.4, 0.4)	1
Slightly Low Importance (SLI)	(0.4, 0.6, 0.3)	1/3
Low Importance (LI)	(0.3, 0.7, 0.2)	1/5
Very Low Importance (VLI)	(0.2, 0.8, 0.1)	1/7
Absolutely Low Importance (ALI)	(0.1, 0.9, 0.0)	1/9

This is carried out for the AMI, VHI, HI, SMI, and EI terms, and

$$\frac{1}{SI} = \frac{1}{\sqrt{\left|100 * \ [(\mu_{\widetilde{A}_S} - \pi_{\widetilde{A}_S})^2 - (v_{\widetilde{A}_S} - \pi_{\widetilde{A}_S})^2]\right|}} \tag{19}$$

is calculated for the EI, SLI, LI, VLI, and ALI levels.

Step 3: All pairwise comparison matrices need a consistency check for the consistent ratio (CR), in which the CR must be less than 10%.

Step 4: Calculate the criterion and alternative spherical fuzzy weights. Determine the weight of each alternative using the SWAM operator via Equation (20):

$$\begin{aligned} SWAM_w(\widetilde{A}_{S1}, \ldots,\ \widetilde{A}_{Sn}) &= w_1\widetilde{A}_{S1} + w_2\widetilde{A}_{S2} + \ldots + w_n\widetilde{A}Sn \\ &= \langle [1 - \prod_{i=1}^{n} (1 - \mu^2_{\widetilde{A}_{Si}})^{w_i}]^{1/2}, \\ &\prod_{i=1}^{n} v^{w_i}_{\widetilde{A}_{Si}}, [\prod_{i=1}^{n} (1 - \mu^2_{\widetilde{A}_{Si}})^{w_i} - \prod_{i=1}^{n} (1 - \mu^2_{\widetilde{A}_{Si}} - \pi^2_{\widetilde{A}_{Si}})^{w_i}]^{1/2} \rangle \end{aligned} \tag{20}$$

where $w = 1/n$.

Step 5: The defuzzification global weights to estimate the final ranking orders for the alternatives are obtained using Equation (21):

$$S(\widetilde{w}^s_j) = \sqrt{\left|100 * \ [(3\mu_{\widetilde{A}_S} - \frac{\pi_{\widetilde{A}_S}}{2})^2 - (\frac{v_{\widetilde{A}_S}}{2} - \pi_{\widetilde{A}_S})^2]\right|} \tag{21}$$

Normalize the criteria weights using Equation (22) and apply the spherical fuzzy multiplication given in Equation (23):

$$\overline{w}^s_j = \frac{S\ (\widetilde{w}^s_j)}{\sum_{j=1}^{n} S(\widetilde{w}^s_j)} \tag{22}$$

$$\begin{aligned} \widetilde{A}_{S_{ij}} = \overline{w}^s_j.\ \widetilde{A}_{S_i} = \langle (1 - (1 - \mu^2_{\widetilde{A}_S})^{w_j^{-s}})^{1/2},\ v^{\overline{w}^s_j}_{\widetilde{A}_S},\ ((1 - \mu^2_{\widetilde{A}_S})^{w_j^{-s}} \\ -(1 - \mu^2_{\widetilde{A}_S} - \pi^2_{\widetilde{A}_S})^{w_j^{-s}})^{1/2} \rangle\ \forall i \end{aligned} \tag{23}$$

The final SF-AHP score ($\widetilde{F}$) for each alternative i is derived by adding the global preference weights and can be calculated by Equation (24) or Equation (25):

$$\widetilde{F} = \sum_{j=1}^{n} \widetilde{A}_{S_{ij}} =\ \widetilde{A}_{S_{i1}} \oplus\ \widetilde{A}_{S_{i2}} \ldots \oplus\ \widetilde{A}_{S_{in}} \forall i \tag{24}$$

$$\prod_{j=1}^{n} \widetilde{A}_{S_{ij}} = \widetilde{A}_{S_{i1}} \otimes \widetilde{A}_{S_{i2}} \ldots \otimes \widetilde{A}_{S_{in}} \tag{25}$$

3.3. Fuzzy Weighted Aggregated Sum Product Assessment (WASPAS-F)

The WASPAS method was proposed by Chakraborty and Zavadskas [89]. This method is a combination of the weighted product model (WPM) and weighted sum model (WSM), which have been applied in many prior studies in recent years [89–95]. An extension of the WASPAS method, WASPAS-F, is used to solve the MCDM problems under a fuzzy environment. The WASPAS-F method is explained as follows.

Step 1: A decision matrix $\widetilde{X} = [\widetilde{x}_{ij}]_{m \times n}$ is constructed, where $\widetilde{x}_{ij}$ is the performance of the ith alternative with respect to the jth criterion, m is the number of alternatives, and n is the number of criteria.

Step 2: Equations (26) and (27) below are used to normalize the decision matrix.

Maximizing the criteria (non-benefit) is expressed as

$$\tilde{\tilde{x}}_{ij} = \frac{\widetilde{x}_{ij}}{max_i \widetilde{x}_{ij}} \tag{26}$$

Minimizing the criteria (non-benefit) is expressed as

$$\tilde{\tilde{x}}_{ij} = \frac{min_i \widetilde{x}_{ij}}{\widetilde{x}_{ij}} \tag{27}$$

Step 3: Compute the weighted ($\widetilde{w}_j$) normalized fuzzy decision matrix for the weighted sum model (WSM) using Equation (28).

$$\widetilde{Q_i} = \sum_{j=1}^{n} \tilde{\tilde{x}}_{ij} \widetilde{w}_j such\ that\ i = 1,\ 2,\ \ldots, m \tag{28}$$

Step 4: Compute the weighted ($\widetilde{w}_j$) normalized fuzzy decision matrix for weighted product model (WPM) using Equation (29):

$$\widetilde{P}_i = \prod_{j=1}^{n} \tilde{\tilde{x}}_{ij}{}^{\widetilde{w}_j} such\ that\ i = 1,\ 2,\ \ldots, m \tag{29}$$

Step 5: Defuzzify the fuzzy performance measurement using the practical center-of-area method as seen in Equations (30) and (31):

$$Q_i = \frac{1}{3}(Q_{ia} + Q_{ib} + Q_{ic}) \tag{30}$$

$$P_i = \frac{1}{3}(P_{ia} + P_{ib} + P_{ic}) \tag{31}$$

where $\widetilde{Q_i} = (Q_{ia}, Q_{ib}, Q_{ic})$ and $\widetilde{P}_i = (P_{ia}, P_{ib}, P_{ic})$ are the fuzzy performance measurements of the WSM and WPM, respectively.

Step 6: Compute the integrated utility function value of FWASPAS using Equation (32) as follows.

$$K_i = \lambda \sum_{j=1}^{n} Q_i + (1 - \lambda) \sum_{j=1}^{n} P_i\ such\ that\ \lambda = 0, \ldots, 1; 0 \le K_i \le 1 \tag{32}$$

The value of λ (i.e., the coefficient value of FWASPAS or the trade-off parameter) is defined based on the assumption that all alternative WSM scores must be equal to the total WPM scores as seen in Equation (33):

$$\lambda = \frac{\sum_{i=1}^{m} P_i}{\sum_{i=1}^{m} Q_i + \sum_{i=1}^{m} P_i} \tag{33}$$

Based on the ranking of preference order, the optimal alternative is the highest value of the utility function K_i.

4. Results Analysis

4.1. A Case Study from Vietnam

To collect the necessary data for this research, a quantitative approach was utilized in conjunction with questionnaires. Data were obtained in compliance with COVID-19 using an online questionnaire survey of 15 experts. Data collection was performed referring to the key knowledgeable people in health care management and the disease control department. Three experts worked for the Ministry of Health in Vietnam, five scholars worked at medical universities, and the remaining group was experienced doctors and nurses serving in the highly disease-affected areas (Ha Noi, Ho Chi Minh, Binh Duong, Da Nang, Long An, and Tien Giang).

This study proposes a hybrid SF-AHP and WASPAS-F model to determine the rankings of 15 intervention alternatives. Additionally, a comparison analysis was performed to demonstrate the reliability and applicability of the suggested method by examining the ranking results obtained using alternative approaches.

The hierarchy decision of the 5 proposed criteria and 15 potential intervention strategies is described in Figure 4 as follows. First, the primary goal was to determine the best government intervention. Second, the assessment criteria were developed and chosen based on a literature review and experts' opinions on the issue. Third, there were 15 potential intervention strategies against COVID-19 applied in numerous countries which were considered as alternatives in Vietnam. Finally, a decision hierarchy was constructed. After selecting the criteria and alternatives, a hierarchy was built with the objective placed on the top, the criteria on the second level, and the alternatives on the third level.

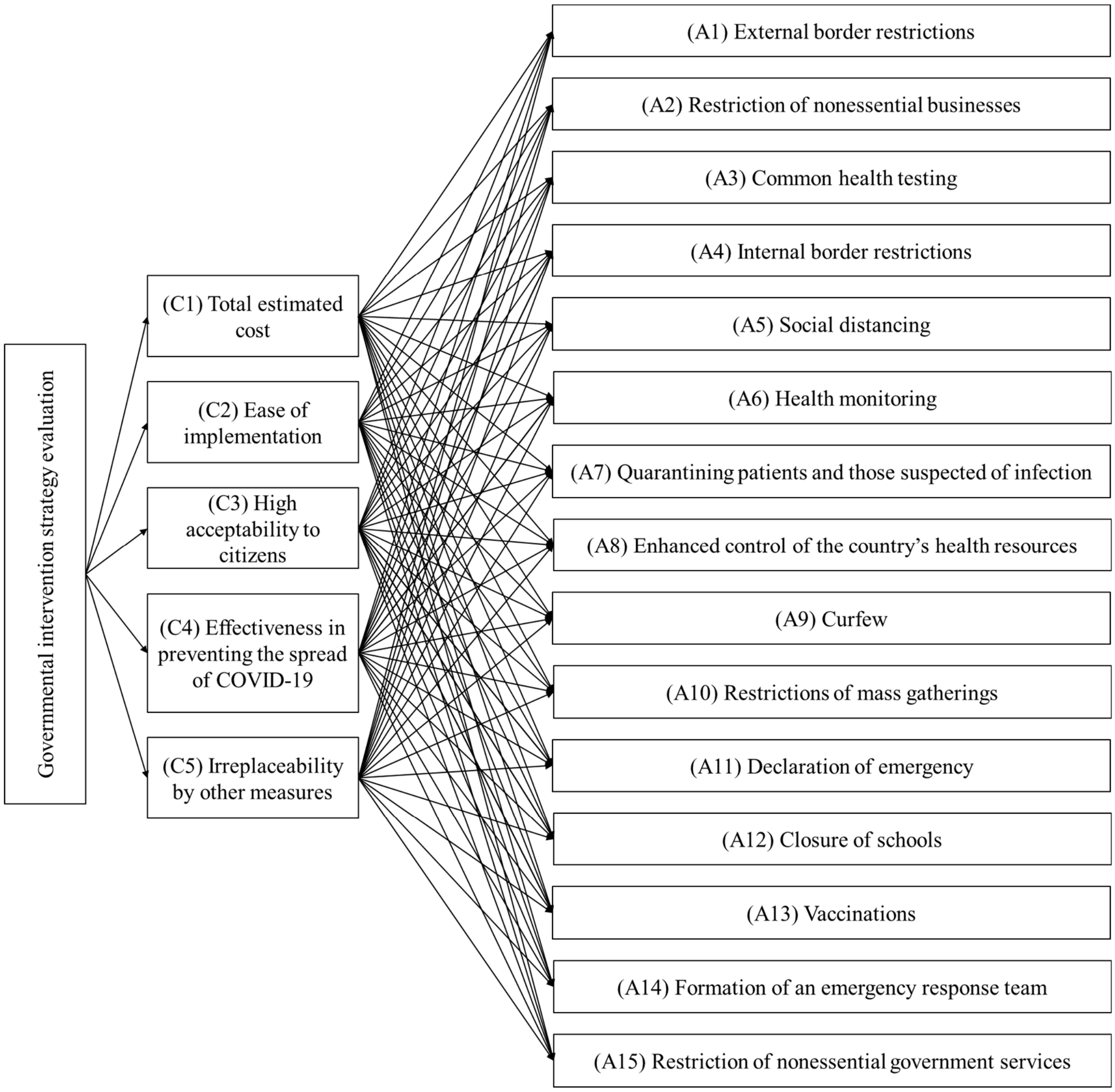

Figure 4. The hierarchical tree of criteria and intervention alternatives for governmental intervention strategy evaluation.

4.2. Results of SF-AHP

In Phase 1, the following SF-AHP procedure presents the demonstration of five main criteria. The same procedures were applied to calculate the relative importance of each governmental intervention with respect to each criterion. First, a panel of 15 experts serving as decision makers evaluated the five proposed criteria in relation to the objective of governmental intervention evaluation, and the consolidated pairwise comparisons of the main criteria were structured by experts using linguistic terms. Second, the CR calculations were applied to test the consistency of the pairwise comparison matrix, as can be seen in Tables 2–4. The CR of the pairwise comparison matrices was calculated as follows:

$$C_{12} = \frac{SI_{C_{12}}}{SUM_{C_2}} = \frac{0.241}{6.021} = 0.040$$

$$MEAN_{C_1} = \frac{0.069+0.040+0.068+0.080+0.107}{5} = 0.073$$

$$WSV = \begin{bmatrix} 1.000 & 0.241 & 0.436 & 0.155 & 1.787 \\ 4.144 & 1.000 & 1.597 & 0.254 & 4.639 \\ 2.292 & 0.626 & 1.000 & 0.316 & 4.534 \\ 6.463 & 3.938 & 3.162 & 1.000 & 4.800 \\ 0.559 & 0.216 & 0.221 & 0.208 & 1.000 \end{bmatrix} \times \begin{bmatrix} 0.073 \\ 0.222 \\ 0.171 \\ 0.480 \\ 0.055 \end{bmatrix} = \begin{bmatrix} 0.374 \\ 1.174 \\ 0.879 \\ 2.628 \\ 0.281 \end{bmatrix}$$

$$CV = \begin{bmatrix} 0.374 \\ 1.174 \\ 0.879 \\ 2.628 \\ 0.281 \end{bmatrix} / \begin{bmatrix} 0.073 \\ 0.222 \\ 0.171 \\ 0.480 \\ 0.055 \end{bmatrix} = \begin{bmatrix} 5.134 \\ 5.289 \\ 5.153 \\ 5.481 \\ 5.091 \end{bmatrix}$$

Table 2. Pair-wise comparison matrix of criteria.

Criteria	Left Criteria Is Greater					Right Criteria Is Greater				Criteria
	AMI	VHI	HI	SMI	EI	SLI	LI	VLI	ALI	
C1					1	5	5	4		C2
C1				1	4	5	5			C3
C1						2	3	4	6	C4
C1			2	6	6	1				C5
C2			3	5	4	3				C3
C2					2	4	4	5		C4
C2		6	5	3	1					C5
C3				1	3	2	4	5		C4
C3	1	3	5	6						C5
C4		6	6	2	1					C5

Table 3. Crisp matrix for the CR.

Criteria	C1	C2	C3	C4	C5
C1	1.000	0.241	0.436	0.155	1.787
C2	4.144	1.000	1.597	0.254	4.639
C3	2.292	0.626	1.000	0.316	4.534
C4	6.463	3.938	3.162	1.000	4.800
C5	0.559	0.216	0.221	0.208	1.000
SUM	14.459	6.021	6.416	1.933	16.761

Table 4. Normalized matrix for the CR.

	C1	C2	C3	C4	C5	MEAN	WSV	CV
C1	0.069	0.040	0.068	0.080	0.107	0.073	0.374	5.134
C2	0.287	0.166	0.249	0.131	0.277	0.222	1.174	5.289
C3	0.159	0.104	0.156	0.164	0.271	0.171	0.879	5.153
C4	0.447	0.654	0.493	0.517	0.286	0.480	2.628	5.481
C5	0.039	0.036	0.034	0.108	0.060	0.056	0.281	5.091

With the five main criteria (n = 5), the largest eigenvector (λ_{max}) was computed to identify the consistency index (CI), the random index (RI), and CR as follows:

$$\lambda_{max} = \frac{5.134 + 5.289 + 5.153 + 5.481 + 5.091}{5} = 5.230 CI = \frac{\lambda_{max} - n}{n - 1} = \frac{5.230 - 5}{5 - 1} = 0.057$$

where n = 5, RI = 1.12, and the CR value is calculated as follows:

$$CR = \frac{CI}{RI} = \frac{0.057}{1.12} = 0.051$$

As the result of CR = 0.051 ≤ 0.1, the pairwise comparison matrix was consistent, and the result was satisfactory.

Third, we integrated a spherical fuzzy comparison matrix (Table 5). Next, the obtained SF-AHP weights were calculated, as can be seen in Table 6. For demonstration, we calculated the weight of criteria C1 as follows.

Table 5. Integrated spherical fuzzy comparison matrix.

	C1	**C2**	**C3**	**C4**	**C5**
C1	(0.500, 0.400, 0.400)	(0.307, 0.694, 0.221)	(0.396, 0.592, 0.293)	(0.180, 0.823, 0.118)	(0.554, 0.408, 0.336)
C2	(0.664, 0.336, 0.2480	(0.500, 0.400, 0.400)	(0.544, 0.438, 0.318)	(0.303, 0.696, 0.221)	(0.700, 0.300, 0.222)
C3	(0.552, 0.422, 0.313)	(0.410, 0.571, 0.310)	(0.500, 0.400, 0.400)	(0.316, 0.682, 0.227)	(0.687, 0.323, 0.233)
C4	(0.786, 0.235, 0.158)	(0.652, 0.341, 0.257)	(0.618, 0.372, 0.270)	(0.500, 0.400, 0.400)	(0.707, 0.292, 0.214)
C5	(0.395, 0.571, 0.329)	(0.275, 0.724, 0.197)	(0.288, 0.716, 0.209)	(0.270, 0.729, 0.190)	(0.500, 0.400, 0.400)

Table 6. Results of SF-AHP weights.

	SF-AHP Weights (μ,v,π)	**Calculations to Obtain Crisp Weights** $S(\tilde{w}^s)$	**Crisp Weights** $\tilde{w}^s$
C1	(0.417, 0.560, 0.305)	10.997	0.160
C2	(0.573, 0.415, 0.290)	15.714	0.228
C3	(0.520, 0.463, 0.305)	14.068	0.204
C4	(0.670, 0.322, 0.260)	18.768	0.272
C5	(0.361, 0.613, 0.290)	9.387	0.136

The following was calculated for the spherical fuzzy weights of criteria C1 with $(\mu, v, \pi) = (0.417,\ 0.560,\ 0.305)$:

$$\mu_{C1} = [1 - \prod_{i=1}^{n} (1 - \mu_{A_{Si}}^2)^{w_i}]^{1/2}$$
$$= [1 - (1 - 0.5^2)^{\frac{1}{5}} * (1 - 0.307^2)^{\frac{1}{5}} * (1 - 0.396^2)^{\frac{1}{5}} * (1 - 0.180^2)^{\frac{1}{5}} * (1 - 0.554^2)^{\frac{1}{5}}]^{1/2} = 0.417$$

$$v_{C1} = \prod_{i=1}^{n} v_{A_{Si}}^{w_i} = 0.4^{\frac{1}{5}} * 0.694^{\frac{1}{5}} * 0.592^{\frac{1}{5}} * 0.823^{\frac{1}{5}} * 0.408^{\frac{1}{5}} = 0.560$$

$$\pi_{C1} = [\prod_{i=1}^{n} (1 - \mu_{A_{Si}}^2)^{w_i} - \prod_{i=1}^{n} (1 - \mu_{A_{Si}}^2 - \pi_{A_{Si}}^2)^{w_i}]^{\frac{1}{2}}$$
$$= [(1 - 0.5^2)^{\frac{1}{5}} * (1 - 0.307^2)^{\frac{1}{5}} * (1 - 0.396^2)^{\frac{1}{5}} * (1 - 0.180^2)^{\frac{1}{5}} * (1 - 0.554^2)^{\frac{1}{5}}$$
$$- (1 - 0.5^2 - 0.4^2)^{\frac{1}{5}} * (1 - 0.307^2 - 0.221^2)^{\frac{1}{5}} * (1 - 0.396^2 - 0.293^2)^{\frac{1}{5}}$$
$$* (1 - 0.180^2 - 0.118^2)^{\frac{1}{5}} * (1 - 0.554^2 - 0.336^2)^{\frac{1}{5}}]^{\frac{1}{2}} = 0.305$$

$$S\ (\tilde{w}_{C1}^s) = \sqrt{\left|100 * [(3\mu_{\overline{A}_s} - \frac{\pi_{\overline{A}_s}}{2})^2 - (\frac{v_{\overline{A}_s}}{2} - \pi_{\overline{A}_s})^2]\right|} = \sqrt{\left|100 * [(3 * 0.417 - \frac{0.305}{2})^2 - (\frac{0.560}{2} - 0.305)^2]\right|}$$
$$= 10.977$$

$$\overline{w}_{C1}^s = \frac{S\ (\tilde{w}_j^s)}{\sum_{J=1}^{n} S(\tilde{w}_j^s)} = \frac{10.977}{10.977 + 15.714 + 14.068 + 18.768 + 9.387} = 0.160$$

The SF-AHP weights of the main criteria included three values: the degree of membership (μ); non-membership (v); and hesitancy (π) of the element $x \in X$. As the results of the abovementioned calculations, the crisp weights of the five main criteria were determined. The most significant criterion for intervention strategy selection was specified as "(C4) effectiveness in preventing the spread of COVID-19" with a value of 0.272, followed by "(C2) ease of implementation" with a value of 0.228. Meanwhile, "(C3) high acceptability to citizens" was ranked at the third position with a value of 0.204. "(C5) irreplaceability by other measures" was the least significant criterion with a value of 0.136.

4.3. Results of WASPAS-F

In Phase 2, this study deployed the SF-AHP weights to combine with the WASPAS- F model for ranking 15 potential intervention strategies. The weighted normalized matrix for the WSM and weighted normalized matrix for the WPM are shown in Tables 7 and 8.

Table 7. Weighted normalized matrix for the WSM.

	C1	C2	C3	C4	C5
A1	(0.1098, 0.2154, 0.2058)	(0.2419, 0.2673, 0.2448)	(0.2864, 0.3623, 0.2977)	(0.2200, 0.1695, 0.1895)	(0.0347, 0.0735, 0.0490)
A2	(0.1065, 0.2029, 0.1952)	(0.1358, 0.1782, 0.1868)	(0.2380, 0.3121, 0.2670)	(0.1662, 0.1412, 0.1686)	(0.0461, 0.1114, 0.0892)
A3	(0.1321, 0.2801, 0.3046)	(0.1697, 0.2120, 0.2126)	(0.2461, 0.3265, 0.2764)	(0.3666, 0.2425, 0.2387)	(0.0350, 0.0742, 0.0504)
A4	(0.0994, 0.1819, 0.1586)	(0.1994, 0.2304, 0.2212)	(0.1614, 0.2260, 0.2126)	(0.2444, 0.1860, 0.2027)	(0.0578, 0.1531, 0.1289)
A5	(0.0940, 0.1687, 0.1437)	(0.2758, 0.2919, 0.2620)	(0.1856, 0.2691, 0.2434)	(0.4546, 0.2801, 0.2596)	(0.0367, 0.0808, 0.0570)
A6	(0.0923, 0.1647, 0.1384)	(0.2504, 0.2734, 0.2491)	(0.2541, 0.3336, 0.2812)	(0.2004, 0.1601, 0.1838)	(0.0391, 0.0865, 0.0610)
A7	(0.1147, 0.2296, 0.2240)	(0.1825, 0.2181, 0.2147)	(0.2380, 0.3193, 0.2741)	(0.4057, 0.2589, 0.2482)	(0.0344, 0.0714, 0.0464)
A8	(0.1110, 0.2154, 0.2058)	(0.2843, 0.2980, 0.2663)	(0.3268, 0.3874, 0.3048)	(0.2786, 0.2048, 0.2160)	(0.0350, 0.0735, 0.0490)
A9	(0.1098, 0.2154, 0.2004)	(0.3692, 0.3502, 0.2899)	(0.3187, 0.3839, 0.3048)	(0.1369, 0.1201, 0.1497)	(0.0352, 0.0728, 0.0477)
A10	(0.1257, 0.2546, 0.2379)	(0.0891, 0.1413, 0.1611)	(0.1654, 0.2404, 0.2245)	(0.1271, 0.1153, 0.1459)	(0.0510, 0.1290, 0.1054)
A11	(0.1147, 0.2259, 0.2115)	(0.0849, 0.1352, 0.1568)	(0.1735, 0.2511, 0.2315)	(0.0880, 0.0894, 0.1232)	(0.0401, 0.0907, 0.0669)
A12	(0.0835, 0.1400, 0.1072)	(0.3013, 0.3103, 0.2727)	(0.1493, 0.2332, 0.2245)	(0.1662, 0.1436, 0.1724)	(0.0310, 0.0593, 0.0351)
A13	(0.1122, 0.2223, 0.2176)	(0.2928, 0.3041, 0.2706)	(0.2703, 0.3480, 0.2882)	(0.3373, 0.2307, 0.2312)	(0.0377, 0.0826, 0.0580)
A14	(0.0966, 0.1708, 0.1410)	(0.2164, 0.2488, 0.2384)	(0.1452, 0.2260, 0.2197)	(0.1809, 0.1530, 0.1800)	(0.0818, 0.2625, 0.2899)
A15	(0.0751, 0.1167, 0.0819)	(0.0849, 0.1321, 0.1525)	(0.0766, 0.1435, 0.1583)	(0.0733, 0.0777, 0.1118)	(0.0667, 0.1885, 0.1740)

Table 8. Weighted normalized matrix for the WPM.

	C1	C2	C3	C4	C5
A1	(0.6659, 0.5855, 0.8490)	(0.7788, 0.8334, 0.9077)	(0.8336, 0.8929, 0.9878)	(0.7490, 0.8126, 0.8099)	(0.5069, 0.2729, 0.5261)
A2	(0.6596, 0.5663, 0.8306)	(0.6588, 0.7044, 0.7775)	(0.7879, 0.8334, 0.9334)	(0.6964, 0.7662, 0.7491)	(0.5506, 0.3520, 0.6532)
A3	(0.7044, 0.6782, 1.0000)	(0.7028, 0.7570, 0.8372)	(0.7959, 0.8509, 0.9505)	(0.8552, 0.9121, 0.9455)	(0.5081, 0.2746, 0.5315)
A4	(0.6459, 0.5325, 0.7616)	(0.7365, 0.7837, 0.8564)	(0.6999, 0.7177, 0.8292)	(0.7698, 0.8373, 0.8474)	(0.5878, 0.4278, 0.7460)
A5	(0.6351, 0.5106, 0.7308)	(0.8091, 0.8644, 0.9436)	(0.7303, 0.7780, 0.8895)	(0.9043, 0.9556, 1.0000)	(0.5154, 0.2891, 0.5557)
A6	(0.6316, 0.5038, 0.7196)	(0.7867, 0.8413, 0.9168)	(0.8038, 0.8595, 0.9589)	(0.7311, 0.7978, 0.7936)	(0.5247, 0.3014, 0.5695)
A7	(0.6747, 0.6067, 0.8795)	(0.7177, 0.7660, 0.8421)	(0.7879, 0.8422, 0.9462)	(0.8780, 0.9317, 0.9705)	(0.5057, 0.2680, 0.5158)
A8	(0.6681, 0.5855, 0.8490	(0.8162, 0.8719, 0.9525)	(0.8678, 0.9211, 1.0000)	(0.7964, 0.8638, 0.8842)	(0.5081, 0.2729, 0.5261)
A9	(0.6659, 0.5855, 0.8396)	(0.8804, 0.9323, 1.0000)	(0.8612, 0.9171, 1.0000)	(0.6622, 0.7271, 0.6916)	(0.5093, 0.2712, 0.5208)
A10	(0.6939, 0.6430, 0.9021)	(0.5831, 0.6398, 0.7141)	(0.7051, 0.7385, 0.8528)	(0.6496, 0.7178, 0.6799)	(0.5669, 0.3850, 0.6939)
A11	(0.6747, 0.6012, 0.8588)	(0.5749, 0.6282, 0.7031)	(0.7155, 0.7536, 0.8667)	(0.5905, 0.6613, 0.6069)	(0.5288, 0.3105, 0.5887)
A12	(0.6125, 0.4600, 0.6468)	(0.8300, 0.8866, 0.9656)	(0.6834, 0.7282, 0.8528)	(0.6964, 0.7703, 0.7603)	(0.4905, 0.2392, 0.4665)
A13	(0.6702, 0.5959, 0.8690)	(0.8232, 0.8793, 0.9612)	(0.8190, 0.8764, 0.9714)	(0.8369, 0.8976, 0.9253)	(0.5193, 0.2931, 0.5591)
A14	(0.6404, 0.5141, 0.7251)	(0.7541, 0.8091, 0.8939)	(0.6777, 0.7177, 0.8434)	(0.7119, 0.7863, 0.7826)	(0.6501, 0.5951, 1.0000)
A15	(0.5930, 0.4153, 0.5779)	(0.5749, 0.6222, 0.6920)	(0.5578, 0.5817, 0.7111)	(0.5632, 0.6319, 0.5688)	(0.6127, 0.4858, 0.8315)

Consequently, the values of Q_i and P_i were the performance scores of each alternative calculated using the weighted sum model (WSP) and weighted product model (WPM), respectively. The final performance score (i.e., the integrated utility function) of each alternative K_i was then calculated from Q_i and P_i. The ranking results of the WASPAS-F model are shown in Table 9. As a result, "(A13) vaccinations" was the optimal strategy, followed by "(A8) enhanced control of the country's health resources", "(A3) common health testing", "(A14) formation of an emergency response team", and "(A7) quarantining patients and those suspected of infection".

Table 9. Ranking the results of the WASPAS-F model.

Alternatives	Q_i	P_i	K_i	Ranking
A1	0.9892	0.1950	0.3269	8
A2	0.8484	0.1720	0.2843	11
A3	1.0558	0.2268	0.3645	3
A4	0.8879	0.2000	0.3142	9
A5	1.0343	0.2036	0.3415	6
A6	0.9227	0.1756	0.2996	10
A7	1.0266	0.2060	0.3422	5
A8	1.0856	0.2262	0.3688	2
A9	1.0349	0.1905	0.3307	7
A10	0.7712	0.1494	0.2526	12
A11	0.6945	0.1107	0.2076	14
A12	0.8099	0.1208	0.2352	13
A13	1.1012	0.2456	0.3877	1
A14	0.9504	0.2397	0.3577	4
A15	0.5712	0.0821	0.1633	15

In comparison to prior research, our findings are consistent with those of Piraveenan et al. [12], who suggested that a successful immunization campaign might aim for regional elimination in the short-to-medium term. As a result, immunization rates will have a direct and significant influence on the dynamics of the COVID-19 pandemic, as well as healthcare systems' ability to contain it. Moreover, governments will require significant resources and infrastructure to address difficulties related to vaccination program execution. Vaccine procurement and supply chain management, developing and deploying vaccine delivery platforms, developing vaccine delivery strategies, identifying eligible target subpopulations for vaccination, training frontline workers, and social mobilization are all obstacles to vaccination program implementation. Furthermore, our findings aligned with the earlier research of Priesemann et al. [13], which outlined the key steps to avoid a SARS-CoV-2 outbreak in Europe. Their research resulted in an action plan for European defense against new SARS-CoV-2 variants, which included measures to achieve and maintain low case numbers with a clear prevention strategy, measures to monitor the virus's spread and individual variants, strategies to stop the virus at the borders and protect the vulnerable, and interventions to improve the efficacy and speed of vaccination.

5. Comparative Analysis

A comparative analysis was conducted to show the reliability and applicability of the proposed methodology. The comparative analysis was performed by comparing the results of WASPAS-F with the results of the Complete SF-AHP approach and Partial SF-AHP approach. The final spherical fuzzy global weights of the alternatives with respect to the evaluation criteria are presented in Table A1, while the final spherical fuzzy global weights of the alternatives with respect to the evaluation criteria are presented in Table A2. The results indicate the robustness of the priority of potential intervention strategies which the Vietnamese government has applied to tackle COVID-19 expansion.

The final rankings of the alternatives according to comparative analysis are shown in Table 10 and Figure 5. The shape in Figure 5 provides a way to quickly understand the rank change for each alternative in different models. The comparative analysis shows that the different approaches could obtain slightly different ranking results, as expected. This may be because of the alternatives having different weighted sums and weighted product values and the different assumptions of each approach. Moreover, the Spearman's rank correlation coefficient [96] was at 0.9821 between the results of the WASPAS-F and Complete SF-AHP approaches and 0.9423 with the results' comparison of the WASPAS-F and Partial SF-AHP approaches. Therefore, it is evident that the three proposed models have good performances to prioritize the 15 potential interventions to prevent the COVID-19 outbreak in the context of Vietnam.

Table 10. Comparisons of ranking results using comparative analysis.

Alternatives	Complete SF-AHP		Partial SF-AHP		SF-AHP and WASPAS-F	
	Overall Score	Ranking	Overall Score	Ranking	Overall Score	Ranking
A1	0.0687	8	0.0691	7	0.3269	8
A2	0.0651	11	0.0646	11	0.2843	11
A3	0.0698	4	0.0697	5	0.3645	3
A4	0.0669	10	0.0662	10	0.3142	9
A5	0.0689	7	0.0684	8	0.3415	6
A6	0.0677	9	0.0676	9	0.2996	10
A7	0.0694	5	0.0693	6	0.3422	5
A8	0.0718	1	0.0726	1	0.3688	2
A9	0.0692	6	0.0700	4	0.3307	7
A10	0.0630	13	0.0631	13	0.2526	12
A11	0.0604	14	0.0611	14	0.2076	14
A12	0.0645	12	0.0636	12	0.2352	13
A13	0.0708	2	0.0710	3	0.3877	1
A14	0.0706	3	0.0713	2	0.3577	4
A15	0.0532	15	0.0524	15	0.1633	15

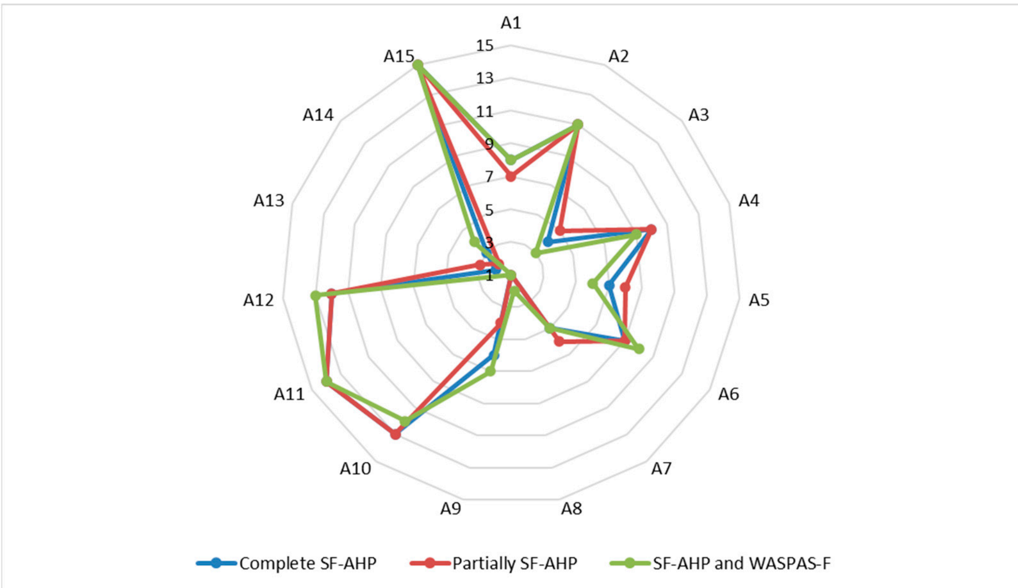

Figure 5. Radar plot for comparative analysis of different models.

6. Managerial Implications

The ongoing outbreak of COVID-19 poses extraordinary hurdles and tremendous problems for many areas around the world. Governments have taken decisive and necessary actions in recent months to halt the development of the COVID-19 contagion. For example, a good case study was carried through on a pan-European level, by which several core measures were designated to prevent the spread, including the urge of efficacy and pace of vaccination [13]. In the context of Vietnam's battle against the pandemic in terms of both the health and economic fronts, it is also necessary to have reasonable policies that strengthen resilience and fully prepare the response capacity during the epidemic's timespan, thus increasing the likelihood of a rapid economic recovery once the disease is controlled and preventing the economy from falling into recession. This research focused on assessing the status quo and measuring government interventions to respond to COVID-19, thereby providing a vital basis for proposing policy recommendations in the coming period to overcome the crisis, build back better, and move toward sustainable development.

In the proposed case study, the practical approach of combining SF-AHP and WASPAS-F has been established. Identification of criteria through experts' opinions and the literature is one of the significant advantages of the present study. The authorities of organizations can utilize the proposed framework to evaluate and determine the optimal strategy in tackling the crisis. The obtained results can be considered a crucial guideline for the organizations in that it does not allow for considering any ineffective and expensive measures in confronting the pandemic. The applied comparative analysis supports decision makers to test observation stability.

7. Conclusions, Limitations, and Future Works

7.1. Conclusions

The COVID-19 pandemic is rapidly spreading all over the world. The severity of the disease, which is worsening by the day, has caused a slew of problems for governments. Although governments have adopted various measures to prevent the spread of the epidemic in their communities, these measures are insufficient, and it is thus vital to ensure that the epidemic is controlled effectively with the most appropriate approach. Almost all governments have selected a strategy and put it into action in their areas. However, established strategies have either been insufficiently valuable for a large number of countries or have been damaging rather than beneficial. Many countries have suffered negative social and environmental consequences, while others have suffered significant impacts on economic growth. As a result, governments' strategies must be assessed and compared. At this point, the problem transforms into an MCDM problem, in which numerous solutions must be evaluated against multiple criteria.

This paper shows a potential application of an MCDM method known as the hybrid SF-AHP and WASPAS-F approach to prioritize criteria while dealing with the COVID-19 outbreak in consultation with different stakeholders. A novel hybrid SF-AHP and WASPAS-F approach can accurately handle stakeholders' qualitative opinions and help make an informed decision.

This study aimed to identify the optimal strategy among various governmental interventions to tackle the COVID-19 outbreak and consider a case study in Vietnam. By interviewing experts and reviewing the literature, the study initially identified and examined the most important criteria, including the total estimated cost, ease of implementation, high acceptability to citizens, effectiveness in preventing the spread of COVID-19, and irreplaceability other measures. Then, 15 strategies were evaluated and compared using MCDM methods. SF-AHP was first used to estimate each criterion's importance for this evaluation, and then WASPAS-F was utilized to rank the alternatives.

The most important findings and contributions of this study are listed below:

- The most effective strategy was successfully determined by the novel combined approach of SF-AHP and WASPAS-F;
- The criteria of "effectiveness in preventing the spread of COVID-19", "ease of implementation", and "high acceptability to citizens" were recognized as the most essential criteria in the SF-AHP method, as shown in Table 6;
- From the final ranking of WASPAS-F, "vaccinations", "enhanced control of the country's health resources", "common health testing", "formation of an emergency response team", and "quarantining patients and those suspected of infection" were the top five strategies, as shown in Table 9.

A comparative analysis of the WASPAS-F, Complete SF-AHP, and Partial SF-AHP approaches was conducted to support the outcomes of the proposed work. The results illustrate that all methods reached relatively common rankings, in which the abovementioned strategies were in the top three effective measures. This means the applied models were robust in nature.

7.2. Limitations

However, the present study has some limitations which can be solved by future works. This study considered a sample of only 15 decision makers, referring to the key knowledgeable people in health care management and the disease control department. (Three experts worked for the Ministry of Health in Vietnam, five scholars worked at medical universities, and the remaining group was experienced doctors and nurses serving in the highly disease-infected areas) Additionally, this study did not consider various decision makers from other categories such as administrators, ministers, or government representatives, who play various critical roles in decision making and practical implementations of those decisions in any country.

Moreover, the authors prioritized a set of 15 governmental strategies in this study. As of now, COVID-19 and its impact are less known to the world, and everyone is struggling to devise effective strategies. Thus, the range of proposed criteria leading to selecting potential government interventions varies between countries. Therefore, the number of criteria and strategies can be further added or removed in the future with respect to the development and understanding of the COVID-19 pandemic.

7.3. Future Works

Researchers are recommended to re-conduct this process to check the applicability of the proposed work, as it is cumbersome to track how long the pandemic will persist. More novel and robust intervention strategies and various other potentially quantitative factors can constitute a future investigation. Methodologically, the proposed methods can be applied to evaluate other countries' intervention strategies for fighting against the current global crisis and future similar pandemics.

For future research, this work can be further extended by applying other MCDM methods. Further extension can be performed by incorporating uncertainty in the form of fuzzy, hesitant fuzzy, intuitionistic fuzzy, neutrosophic fuzzy, or probabilistic information. A comparison with this work may provide more insight.

Author Contributions: Conceptualization, P.-H.N. and T.-T.D.; methodology, P.-H.N. and T.-T.D.; software, P.-H.N. and K.-A.N.; validation, J.-F.T. and M.-H.L.; formal analysis, J.-F.T. and M.-H.L.; investigation, P.-H.N.; resources, J.-F.T.; data curation, T.-T.D. and H.-A.P.; writing—original draft preparation, P.-H.N. and T.-T.D.; writing—review and editing, J.-F.T. and M.-H.L.; visualization, P.-H.N. and T.-T.D.; supervision, J.-F.T. and M.-H.L.; project administration, P.-H.N.; funding acquisition, P.-H.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Decision no 1097/QD-DHFPT, FPT University, Vietnam. It was also supported in part by the Ministry of Science and Technology in Taiwan under Grant MOST 109-2410-H-027-012-MY2.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Supplementary data to this article can be found online at http://dx.doi.org/10.17632/5ym9hgswk5.1 (accessed on 5 October 2021).

Acknowledgments: The authors would like to express sincere thanks and gratitude to the experts and policymakers from the Ministry of Health in Vietnam for their collaborations and contributions to this research.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Complete SF-AHP results.

	C1			C2			C3			C4			C5			Total			Score	Rank	Weight
	μ	v	π	μ	v	π	μ	v	π	μ	v	π	μ	v	π	μ	v	π			
A1	0.214	0.688	0.356	0.284	0.601	0.390	0.262	0.637	0.381	0.334	0.565	0.370	0.183	0.718	0.343	0.546	0.107	0.512	13.046	8	0.069
A2	0.189	0.710	0.350	0.263	0.636	0.373	0.247	0.647	0.372	0.327	0.567	0.376	0.161	0.746	0.334	0.517	0.123	0.487	12.352	11	0.065
A3	0.196	0.707	0.360	0.273	0.626	0.370	0.269	0.626	0.385	0.362	0.537	0.367	0.184	0.718	0.357	0.554	0.107	0.517	13.253	4	0.070
A4	0.184	0.720	0.355	0.282	0.617	0.364	0.249	0.649	0.371	0.346	0.552	0.379	0.154	0.758	0.327	0.532	0.121	0.503	12.699	10	0.067
A5	0.197	0.704	0.361	0.275	0.619	0.366	0.252	0.648	0.371	0.370	0.521	0.374	0.163	0.744	0.335	0.549	0.110	0.517	13.086	7	0.069
A6	0.185	0.720	0.340	0.292	0.604	0.379	0.259	0.636	0.382	0.329	0.575	0.358	0.178	0.727	0.345	0.537	0.116	0.503	12.847	9	0.068
A7	0.200	0.706	0.345	0.260	0.646	0.356	0.257	0.636	0.377	0.366	0.519	0.385	0.190	0.711	0.364	0.550	0.107	0.511	13.166	5	0.069
A8	0.223	0.673	0.370	0.303	0.588	0.388	0.288	0.600	0.387	0.340	0.553	0.382	0.191	0.709	0.362	0.571	0.093	0.531	13.635	1	0.072
A9	0.201	0.704	0.353	0.325	0.561	0.398	0.272	0.623	0.387	0.294	0.620	0.344	0.192	0.709	0.351	0.549	0.108	0.512	13.134	6	0.069
A10	0.223	0.672	0.363	0.245	0.663	0.352	0.225	0.680	0.354	0.304	0.605	0.352	0.157	0.757	0.320	0.499	0.139	0.472	11.957	13	0.063
A11	0.228	0.665	0.374	0.239	0.671	0.344	0.215	0.697	0.341	0.261	0.673	0.316	0.165	0.743	0.333	0.477	0.155	0.449	11.471	14	0.060
A12	0.171	0.736	0.338	0.263	0.632	0.366	0.240	0.657	0.372	0.336	0.561	0.365	0.152	0.760	0.327	0.512	0.130	0.484	12.246	12	0.065
A13	0.208	0.686	0.366	0.311	0.579	0.381	0.260	0.634	0.370	0.349	0.546	0.375	0.183	0.715	0.352	0.563	0.098	0.526	13.431	2	0.071
A14	0.205	0.692	0.358	0.319	0.573	0.398	0.278	0.610	0.386	0.324	0.562	0.382	0.191	0.711	0.348	0.562	0.097	0.525	13.404	3	0.071
A15	0.170	0.743	0.333	0.215	0.703	0.327	0.184	0.742	0.315	0.234	0.704	0.289	0.149	0.765	0.322	0.416	0.209	0.393	10.097	15	0.053

Table A2. Partial SF-AHP results.

	C1			C2			C3			C4			C5			Total			Score	Rank	Weight
	μ	v	π	μ	v	π	μ	v	π	μ	v	π	μ	v	π	μ	v	π			
A1	0.218	0.890	0.143	0.250	0.845	0.188	0.240	0.866	0.172	0.274	0.823	0.191	0.199	0.903	0.134	0.502	0.485	0.490	12.375	7	0.069
A2	0.190	0.903	0.138	0.229	0.865	0.175	0.225	0.872	0.163	0.267	0.825	0.195	0.173	0.919	0.130	0.468	0.516	0.458	11.572	11	0.065
A3	0.197	0.901	0.147	0.239	0.860	0.172	0.248	0.859	0.175	0.300	0.806	0.190	0.200	0.903	0.148	0.507	0.485	0.493	12.491	5	0.070
A4	0.184	0.908	0.144	0.247	0.855	0.167	0.228	0.873	0.162	0.285	0.816	0.200	0.164	0.925	0.125	0.480	0.511	0.471	11.863	10	0.066
A5	0.198	0.899	0.148	0.241	0.856	0.168	0.230	0.872	0.163	0.308	0.796	0.197	0.174	0.918	0.130	0.498	0.491	0.487	12.258	8	0.068
A6	0.185	0.908	0.131	0.257	0.847	0.181	0.237	0.866	0.173	0.269	0.829	0.181	0.193	0.909	0.137	0.490	0.501	0.478	12.103	9	0.068
A7	0.202	0.901	0.134	0.226	0.870	0.161	0.236	0.865	0.167	0.303	0.794	0.205	0.208	0.899	0.154	0.503	0.484	0.489	12.414	6	0.069
A8	0.229	0.881	0.155	0.269	0.837	0.188	0.268	0.842	0.177	0.279	0.817	0.201	0.209	0.897	0.152	0.530	0.455	0.514	13.006	1	0.073
A9	0.203	0.900	0.142	0.291	0.818	0.199	0.252	0.858	0.177	0.238	0.854	0.169	0.211	0.897	0.142	0.509	0.484	0.495	12.548	4	0.070
A10	0.229	0.880	0.148	0.212	0.879	0.158	0.203	0.889	0.149	0.247	0.846	0.176	0.167	0.925	0.119	0.456	0.538	0.448	11.305	13	0.063
A11	0.234	0.875	0.159	0.206	0.883	0.152	0.194	0.897	0.141	0.210	0.879	0.150	0.177	0.918	0.128	0.440	0.559	0.431	10.940	14	0.061
A12	0.170	0.916	0.131	0.229	0.863	0.168	0.218	0.877	0.164	0.276	0.821	0.187	0.162	0.926	0.126	0.460	0.527	0.451	11.388	12	0.064
A13	0.211	0.889	0.151	0.277	0.831	0.182	0.239	0.864	0.161	0.288	0.812	0.196	0.199	0.902	0.142	0.517	0.468	0.504	12.710	3	0.071
A14	0.207	0.893	0.144	0.285	0.827	0.199	0.257	0.849	0.175	0.265	0.822	0.200	0.210	0.899	0.140	0.520	0.463	0.505	12.772	2	0.071
A15	0.169	0.919	0.128	0.185	0.898	0.141	0.164	0.917	0.124	0.186	0.893	0.130	0.159	0.929	0.122	0.375	0.628	0.369	9.389	15	0.052

References

1. Ragab, D.; Salah Eldin, H.; Taeimah, M.; Khattab, R.; Salem, R. The COVID-19 Cytokine Storm; What We Know So Far. *Front. Immunol.* **2020**, *11*, 1446. [CrossRef]
2. Nguyen, P.H.; Tsai, J.F.; Kayral, I.E.; Lin, M.H. Unemployment rates forecasting with grey-based models in the post-COVID-19 period: A case study from Vietnam. *Sustainability* **2021**, *13*, 7879. [CrossRef]
3. Nguyen, P.H.; Tsai, J.F.; Nguyen, H.P.; Nguyen, V.T.; Dao, T.K. Assessing the Unemployment Problem Using A Grey MCDM Model under COVID-19 Impacts: A Case Analysis from Vietnam. *J. Asian Financ. Econ. Bus.* **2020**, *7*, 53–62. [CrossRef]
4. Huynh, G.; Tran, T.T.; Nguyen, H.T.N.; Pham, L.A. COVID-19 vaccination intention among healthcare workers in Vietnam. *Asian Pac. J. Trop. Med.* **2021**, *14*, 159–164. [CrossRef]
5. Samanlioglu, F.; Kaya, B.E. Evaluation of the COVID-19 Pandemic Intervention Strategies with Hesitant F-AHP. *J. Healthc. Eng.* **2020**, *2020*. [CrossRef] [PubMed]
6. Furati, K.M.; Sarumi, I.O.; Khaliq, A.Q.M. Fractional model for the spread of COVID-19 subject to government intervention and public perception. *Appl. Math. Model.* **2021**, *95*, 89–105. [CrossRef] [PubMed]
7. Aquino, E.M.L.; Silveira, I.H.; Pescarini, J.M.; Aquino, R.; de Souza-Filho, J.A. Social distancing measures to control the COVID-19 pandemic: Potential impacts and challenges in Brazil. *Cienc. e Saude Coletiva* **2020**, *25*, 2423–2446. [CrossRef] [PubMed]
8. West, R.; Michie, S.; Rubin, G.J.; Amlôt, R. Applying principles of behaviour change to reduce SARS-CoV-2 transmission. *Nat. Hum. Behav.* **2020**, *4*, 451–459. [CrossRef]
9. Centers for Disease Control and Prevention COVID-19 Vaccine Safety Update. 2021. Available online: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/safety-of-vaccines.html (accessed on 1 September 2021).
10. Cucinotta, D.; Vanelli, M. WHO declares COVID-19 a pandemic. *Acta Biomed.* **2020**, *91*, 157.

11. Centers for Disease Control and Prevention CDC COVID Data Tracker. Cent. Dis. Control. Prev. 2020. Available online: https://covid.cdc.gov/covid-data-tracker/#datatracker-home (accessed on 1 September 2021).
12. Piraveenan, M.; Sawleshwarkar, S.; Walsh, M.; Zablotska, I.; Bhattacharyya, S.; Farooqui, H.H.; Bhatnagar, T.; Karan, A.; Murhekar, M.; Zodpey, S.; et al. Optimal governance and implementation of vaccination programmes to contain the COVID-19 pandemic. *R. Soc. Open Sci.* **2021**, *8*, 210429. [CrossRef]
13. Priesemann, V.; Balling, R.; Brinkmann, M.M.; Ciesek, S.; Czypionka, T.; Eckerle, I.; Giordano, G.; Hanson, C.; Hel, Z.; Hotulainen, P.; et al. An action plan for pan-European defence against new SARS-CoV-2 variants. *Lancet* **2021**, *397*, 469–470. [CrossRef]
14. Aharon, D.Y.; Siev, S. COVID-19, government interventions and emerging capital markets performance. *Res. Int. Bus. Financ.* **2021**, *58*, 101492. [CrossRef]
15. Mardani, A.; Saraji, M.K.; Mishra, A.R.; Rani, P. A novel extended approach under hesitant fuzzy sets to design a framework for assessing the key challenges of digital health interventions adoption during the COVID-19 outbreak. *Appl. Soft Comput. J.* **2020**, *96*, 106613. [CrossRef]
16. Golinelli, D.; Boetto, E.; Carullo, G.; Nuzzolese, A.G.; Landini, M.P.; Fantini, M.P. How the COVID-19 pandemic is favoring the adoption of digital technologies in healthcare: A literature review. *J. Med. Internet Res.* **2020**. [CrossRef]
17. Ross, J.; Stevenson, F.; Dack, C.; Pal, K.; May, C.; Michie, S.; Barnard, M.; Murray, E. Developing an implementation strategy for a digital health intervention: An example in routine healthcare. *BMC Health Serv. Res.* **2018**, *18*, 1–13. [CrossRef]
18. Mendes-Santos, C.; Andersson, G.; Weiderpass, E.; Santana, R. Mitigating COVID-19 Impact on the Portuguese Population Mental Health: The Opportunity That Lies in Digital Mental Health. *Front. Public Health* **2020**, *8*, 599. [CrossRef]
19. Sormunen, M.; Saaranen, T.; Heikkilä, A.; Sjögren, T.; Koskinen, C.; Mikkonen, K.; Kaäriaïnen, M.; Koivula, M.; Salminen, L. Digital Learning Interventions in Higher Education: A Scoping Review. *CIN-Comput. Inform. Nurs.* **2020**, *38*, 613–624. [CrossRef]
20. Männistö, M.; Mikkonen, K.; Vuopala, E.; Kuivila, H.-M.; Virtanen, M.; Kyngäs, H.; Kääriäinen, M. Effects of a digital educational intervention on collaborative learning in nursing education: A quasi-experimental study. *Nord. J. Nurs. Res.* **2019**, *39*, 191–200. [CrossRef]
21. Despres, C.; Aguilar, R.; McAlister, A.; Ramirez, A.G. Communication for Awareness and Action on Inequitable Impacts of COVID-19 on Latinos. *Health Promot. Pract.* **2020**, *21*, 859–861. [CrossRef] [PubMed]
22. Phillips, J.; Babcock, R.A.; Orbinski, J. The digital response to COVID-19: Exploring the use of digital technology for information collection, dissemination and social control in a global pandemic. *J. Bus. Contin. Emerg. Plan.* **2021**, *14*, 333–353.
23. Tan, B.; Martinez Peria, M.; Pierri, N.; Presbitero, A. Government Intervention and Bank Market Power: Lessons from the Global Financial Crisis for the COVID-19 Crisis. IMF Work. Pap. 2020. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3772479 (accessed on 1 September 2021).
24. Pinto Neto, O.; Kennedy, D.M.; Reis, J.C.; Wang, Y.; Brizzi, A.C.B.; Zambrano, G.J.; de Souza, J.M.; Pedroso, W.; de Mello Pedreiro, R.C.; de Matos Brizzi, B.; et al. Mathematical model of COVID-19 intervention scenarios for São Paulo—Brazil. *Nat. Commun.* **2021**, *12*, 418. [CrossRef] [PubMed]
25. Lee, H.; Lee, H.; Song, K.-H.; Kim, E.S.; Park, J.S.; Jung, J.; Ahn, S.; Jeong, E.K.; Park, H.; Kim, H. Bin Impact of Public Health Interventions on Seasonal Influenza Activity During the COVID-19 Outbreak in Korea. *Clin. Infect. Dis.* **2021**, *73*, e132–e140. [CrossRef] [PubMed]
26. Doherty, F.V.; Odeyemi, O.A.; Adeola, A.; Amolegbe, O.; Ajagbe, F.E. Evaluation of knowledge, impacts and government intervention strategies during the COVID-19 pandemic in Nigeria. *Data Br.* **2020**, *32*, 106177. [CrossRef] [PubMed]
27. Chu, D.K.W.; Gu, H.; Chang, L.D.J.; Cheuk, S.S.Y.; Gurung, S.; Krishnan, P.; Ng, D.Y.M.; Liu, G.Y.Z.; Wan, C.K.C.; Tsang, D.N.C.; et al. SARS-CoV-2 superspread in fitness center, Hong Kong, China, March 2021. *Emerg. Infect. Dis.* **2021**, *27*, 2230–2232. [CrossRef] [PubMed]
28. Sheth, S.A.; Wu, T.C.; Sharrief, A.; Ankrom, C.; Grotta, J.C.; Fisher, M.; Savitz, S.I. Early Lessons from World War COVID Reinventing Our Stroke Systems of Care. *Stroke* **2020**, *51*, 2268–2272. [CrossRef]
29. Bechtold, H.D.; Cruz, A.T.; Kaziny, B.D. From World War II to COVID-19: A Historical Perspective on the American Medical Supply Chain. *Disaster Med. Public Health Prep.* **2021**, 1–2. [CrossRef]
30. Asadi, S.; Nilashi, M.; Abumalloh, R.A.; Samad, S.; Ahani, A.; Ghabban, F.; Yusuf, S.Y.M.; Supriyanto, E. Evaluation of Factors to Respond to the COVID-19 Pandemic Using DEMATEL and Fuzzy Rule-Based Techniques. *Int. J. Fuzzy Syst.* **2021**, *19*, 925–941. [CrossRef]
31. Nguyen, P.H. A Fuzzy Analytic Hierarchy Process (FAHP) Based on SERVQUAL for Hotel Service Quality Management: Evidence from Vietnam. *J. Asian Financ. Econ. Bus.* **2021**, *8*, 1101–1109. [CrossRef]
32. Nguyen, P.H.; Tsai, J.F.; Kumar, V.A.G.; Hu, Y.C. Stock investment of agriculture companies in the Vietnam stock exchange market: An AHP integrated with GRA-TOPSIS-MOORA approaches. *J. Asian Financ. Econ. Bus.* **2020**, *7*, 113–121. [CrossRef]
33. Wang, C.N.; Nguyen, N.A.T.; Dang, T.T.; Lu, C.M. A compromised decision-making approach to third-party logistics selection in sustainable supply chain using fuzzy ahp and fuzzy vikor methods. *Mathematics* **2021**, *9*, 886. [CrossRef]
34. Guo, S.; Zhang, W.; Gao, X. Business risk evaluation of electricity retail company in China using a hybrid MCDM method. *Sustainability* **2020**, *12*, 2040. [CrossRef]

35. Chen, C.H. A new multi-criteria assessment model combining GRA techniques with intuitionistic fuzzy entropy-based TOPSIS method for sustainable building materials supplier selection. *Sustainability* **2019**, *11*, 2265. [CrossRef]
36. Alkan, N.; Kahraman, C. Evaluation of government strategies against COVID-19 pandemic using q-rung orthopair fuzzy TOPSIS method. *Appl. Soft Comput.* **2021**, *110*, 107653. [CrossRef]
37. Abikova, J. Application of fuzzy DEMATEL–ANP methods for siting refugee camps. *J. Humanit. Logist. Supply Chain Manag.* **2020**, *10*, 347–369. [CrossRef]
38. Zadeh, L.A. Fuzzy sets. *Inf. Control* **1965**. [CrossRef]
39. Kutlu Gündoğdu, F.; Kahraman, C. Spherical fuzzy sets and decision making applications. *Adv. Intell. Syst. Comput.* **2020**, *1029*, 979–987. [CrossRef]
40. Ahmad, N.; Hasan, M.G.; Barbhuiya, R.K. Identification and prioritization of strategies to tackle COVID-19 outbreak: A group-BWM based MCDM approach. *Appl. Soft Comput.* **2021**, *111*, 107642. [CrossRef] [PubMed]
41. Lo, H.W.; Shiue, W.; Liou, J.J.H.; Tzeng, G.H. A hybrid MCDM-based FMEA model for identification of critical failure modes in manufacturing. *Soft Comput.* **2020**, *24*, 15733–15745. [CrossRef]
42. Liou, J.J.H.; Tzeng, G.H. Comments on "Multiple criteria decision making (MCDM) methods in economics: An overview". *Technol. Econ. Dev. Econ.* **2012**, *17*, 397–427. [CrossRef]
43. Wang, C.N.; Van Thanh, N.; Chyou, J.T.; Lin, T.F.; Nguyen, T.N. Fuzzy multicriteria decision-making model (MCDM) for raw materials supplier selection in plastics industry. *Mathematics* **2019**, *7*, 981. [CrossRef]
44. Zhang, Q.; Hu, J.; Feng, J.; Liu, A. A novel multiple criteria decision making method for material selection based on GGPFWA operator. *Mater. Des.* **2020**, *195*, 109038. [CrossRef]
45. Mukhamediev, R.I.; Mustakayev, R.; Yakunin, K.; Kiseleva, S.; Gopejenko, V. Multi-criteria spatial decision making supportsystem for renewable energy development in Kazakhstan. *IEEE Access* **2019**, *7*, 122275–122288. [CrossRef]
46. Chien, F.; Wang, C.N.; Nguyen, V.T.; Nguyen, V.T.; Chau, K.Y. An evaluation model of quantitative and qualitative fuzzy multi-criteria decision-making approach for hydroelectric plant location selection. *Energies* **2020**, *13*, 2783. [CrossRef]
47. Kulak, O.; Goren, H.G.; Supciller, A.A. A new multi criteria decision making approach for medical imaging systems considering risk factors. *Appl. Soft Comput. J.* **2015**, *35*, 931–941. [CrossRef]
48. Geetha, S.; Narayanamoorthy, S.; Kang, D.; Kureethara, J.V. A Novel Assessment of Healthcare Waste Disposal Methods: Intuitionistic Hesitant Fuzzy MULTIMOORA Decision Making Approach. *IEEE Access* **2019**, *7*, 130283–130299. [CrossRef]
49. Alizadeh, R.; Soltanisehat, L.; Lund, P.D.; Zamanisabzi, H. Improving renewable energy policy planning and decision-making through a hybrid MCDM method. *Energy Policy* **2020**, *137*, 111174. [CrossRef]
50. Wang, C.N.; Kao, J.C.; Wang, Y.H.; Nguyen, V.T.; Nguyen, V.T.; Husain, S.T. A multicriteria decision-making model for the selection of suitable renewable energy sources. *Mathematics* **2021**, *9*, 1318. [CrossRef]
51. Jiang, P.; Hu, Y.C.; Wang, W.; Jiang, H.; Wu, G. Interval grey prediction models with forecast combination for energy demand forecasting. *Mathematics* **2020**, *8*, 960. [CrossRef]
52. Tsai, J.F.; Wang, C.P.; Lin, M.H.; Huang, S.W. Analysis of key factors for supplier selection in taiwan's thin-film transistor liquid-crystal displays industry. *Mathematics* **2021**, *9*, 396. [CrossRef]
53. Saaty, T.L. The Analytic Hierarchy Process, New York: Mcgrew Hill. In *International, Translated to Russian, Portuguesses and Chinese, Revised Edition, Paperback (1996, 2000)*; RWS Publications: Pittsburgh, PA, USA, 1980; Volume 9, pp. 19–22.
54. Torra, V. Hesitant fuzzy sets. *Int. J. Intell. Syst.* **2010**, *25*, 529–539. [CrossRef]
55. Yager, R.R.; Abbasov, A.M. Pythagorean membership grades, complex numbers, and decision making. *Int. J. Intell. Syst.* **2013**, *28*, 436–452. [CrossRef]
56. Yager, R.R. Generalized orthopair fuzzy sets. *IEEE Trans. Fuzzy Syst.* **2016**, *25*, 1222–1230. [CrossRef]
57. Chen, T. A FAHP-FTOPSIS approach for choosing mid-term occupational healthcare measures amid the COVID-19 pandemic. *Health Policy Technol.* **2021**, *10*, 100517. [CrossRef]
58. Wu, H.C.; Wang, Y.C.; Chen, T.C.T. Assessing and comparing covid-19 intervention strategies using a varying partial consensus fuzzy collaborative intelligence approach. *Mathematics* **2020**, *8*, 1725. [CrossRef]
59. Kutlu Gündoğdu, F.; Kahraman, C. Spherical fuzzy analytic hierarchy process (AHP) and its application to industrial robot selection. In Proceedings of the International Conference on Intelligent and Fuzzy Systems 2019 Conference, Istanbul, Turkey, 23–25 July 2019.
60. Yildiz, D.; Temur, G.T.; Beskese, A.; Bozbura, F.T. A spherical fuzzy analytic hierarchy process based approach to prioritize career management activities improving employee retention. *J. Intell. Fuzzy Syst.* **2020**, *39*, 6603–6618. [CrossRef]
61. Nasir, A.; Jan, N.; Yang, M.S.; Khan, S.U. Complex T-Spherical Fuzzy Relations with Their Applications in Economic Relationships and International Trades. *IEEE Access* **2021**, *9*, 66115–66131. [CrossRef]
62. Duleba, S.; Kutlu Gündoğdu, F.; Moslem, S. Interval-Valued Spherical Fuzzy Analytic Hierarchy Process Method to Evaluate Public Transportation Development. *Informatica* **2021**, 1–26. [CrossRef]
63. Piccoli, L.; Dzankic, J.; Ruedin, D. Citizenship, Migration and Mobility in a Pandemic (CMMP): A global dataset of COVID-19 restrictions on human movement. *PLoS ONE* **2021**, *16*, e0248066. [CrossRef] [PubMed]
64. Mateus, A.L.P.; Otete, H.E.; Beck, C.R.; Dolan, G.P.; Nguyen-Van-Tam, J.S. Effectiveness of travel restrictions in the rapid containment of human influenza: A systematic review. *Bull. World Health Organ.* **2014**, *92*, 868–880. [CrossRef] [PubMed]

65. Lauer, S.A.; Grantz, K.H.; Bi, Q.; Jones, F.K.; Zheng, Q.; Meredith, H.R.; Azman, A.S.; Reich, N.G.; Lessler, J. The incubation period of coronavirus disease 2019 (CoVID-19) from publicly reported confirmed cases: Estimation and application. *Ann. Intern. Med.* **2020**, *172*, 577–582. [CrossRef] [PubMed]
66. Porsse, A.A.; de Souza, K.B.; Carvalho, T.S.; Vale, V.A. The economic impacts of COVID-19 in Brazil based on an interregional CGE approach. *Reg. Sci. Policy Pract.* **2020**, *12*, 1105–1121. [CrossRef]
67. Buitrago-Garcia, D.; Egli-Gany, D.; Counotte, M.J.; Hossmann, S.; Imeri, H.; Ipekci, A.M.; Salanti, G.; Low, N. Occurrence and transmission potential of asymptomatic and presymptomatic SARSCoV-2 infections: A living systematic review and meta-analysis. *PLoS Med.* **2020**, *17*, e1003346. [CrossRef]
68. Kahanec, M.; Lafférs, L.; Schmidpeter, B. The impact of repeated mass antigen testing for COVID-19 on the prevalence of the disease. *J. Popul. Econ.* **2021**, *34*, 1105–1140. [CrossRef] [PubMed]
69. Wilder-Smith, A.; Freedman, D.O. Isolation, quarantine, social distancing and community containment: Pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *J. Travel Med.* **2020**, *27*, 1–4. [CrossRef] [PubMed]
70. WHO Considerations for Implementing and Adjusting Public Health and Social Measures in the Context of COVID-19. 2021. Available online: https://www.who.int/publications-detail-redirect/considerations-in-adjusting-public-health-and-social-measures-in-the-context-of-covid-19-interim-guidance (accessed on 1 September 2021).
71. WHO. *Public Health Surveillance for COVID-19*; WHO: Geneve, Switzerland, 2020; Volume 11. [CrossRef]
72. Committee on Modeling Community Containment for Pandemic Influenza. *Modeling Community Containment for Pandemic Influenza: A Letter Report*; The National Academies Press: Washington, DC, USA, 2006; Available online: https://www.nap.edu/catalog/11800/modeling-community-containment-for-pandemic-influenza-a-letter-report (accessed on 1 September 2021).
73. World Health Organization Writing Group Non-pharmaceutical interventions for pandemic influenza, national and community measures. *Emerg. Infect. Dis.* **2006**, *12*, 88–94. [CrossRef]
74. Zhang, Z.; Yao, W.; Wang, Y.; Long, C.; Fu, X. Wuhan and Hubei COVID-19 mortality analysis reveals the critical role of timely supply of medical resources. *J. Infect.* **2020**, *81*, 147–178. [CrossRef] [PubMed]
75. Daugherty Biddison, L.; Berkowitz, K.A.; Courtney, B.; De Jong, M.J.; Devereaux, A.V.; Kissoon, N.; Roxland, B.E.; Sprung, C.L.; Dichter, J.R.; Christian, M.D.; et al. Ethical considerations: Care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. *Chest* **2014**, *146*, e145S–e155S. [CrossRef]
76. Emanuel, E.J.; Wertheimer, A. Who Should Get Influenza Vaccine When Not All Can? *Drugs Alcohol Today* **2009**, *9*, 8–13. [CrossRef]
77. Dechsupa, S.; Assawakosri, S.; Phakham, S.; Honsawek, S. Positive impact of lockdown on COVID-19 outbreak in Thailand. *Travel Med. Infect. Dis.* **2020**, *36*, 19–21. [CrossRef]
78. Mumena, W.A. Impact of COVID-19 curfew on eating habits, food intake, and weight according to food security status in Saudi Arabia: A retrospective study. *Prog. Nutr.* **2020**, *22*, e2020075. [CrossRef]
79. WHO. *Key Planning Recommendations for Mass Gatherings in the Context of the Current COVID-19 Outbreak: Interim Guidance 14 February 2020*; WHO: Geneve, Switzerland, 2020. [CrossRef]
80. Wainwright, J.J.; Mikre, M.; Whitley, P. Analysis of Drug Test Results Before and After the US Declaration of a National Emergency Concerning the COVID-19 Outbreak. *JAMA-J. Am. Med. Assoc.* **2020**, *323*, 1674–1677. [CrossRef] [PubMed]
81. Yamamura, E.; Tsutsui, Y. Impact of the State of Emergency Declaration for COVID-19 on Preventive Behaviors and Mental Conditions in Japan: Difference in Difference Analysis using Panel Data. *arXiv* **2020**, arXiv:2005.13008.
82. Germann, T.C.; Kadau, K.; Longini, I.M.; Macken, C.A. Mitigation strategies for pandemic influenza in the United States. *Proc. Natl. Acad. Sci. USA.* **2006**, *103*, 5935–5940. [CrossRef] [PubMed]
83. Ryu, S.; Gao, H.; Wong, J.Y.; Shiu, E.Y.C.; Xiao, J.; Fong, M.W.; Cowling, B.J. Nonpharmaceutical measures for pandemic influenza in nonhealthcare settings-international travel-related measures. *Emerg. Infect. Dis.* **2020**, *26*, 2298–2299. [CrossRef] [PubMed]
84. Huynh, G.; Nguyen, H.T.N.; Nguyen, V.T.; Pham, A. Le Development and psychometric properties of the health belief scales toward covid-19 vaccine in Ho Chi Minh city, Vietnam. *Risk Manag. Healthc. Policy* **2021**, *14*, 2517. [CrossRef] [PubMed]
85. Pandey, N.; Kaushal, V.; Puri, G.D.; Taneja, S.; Biswal, M.; Mahajan, P.; Guru, R.R.; Malhotra, P.; Sehgal, I.S.; Dhooria, S.; et al. Transforming a General Hospital to an Infectious Disease Hospital for COVID-19 Over 2 Weeks. *Front. Public Health* **2020**, *8*, 1–8. [CrossRef]
86. Herrera, V.; Finkler, N.; Vincent, J. Innovation and Transformation in the Response to Covid-19: Seven Areas Where Clinicians Need to Lead. *NEJM Catal.* **2020**, 1–13. [CrossRef]
87. Ghorui, N.; Ghosh, A.; Mondal, S.P.; Bajuri, M.Y.; Ahmadian, A.; Salahshour, S.; Ferrara, M. Identification of dominant risk factor involved in spread of COVID-19 using hesitant fuzzy MCDM methodology. *Results Phys.* **2021**, *21*, 103811. [CrossRef]
88. Kutlu Gündoğdu, F.; Kahraman, C. A novel spherical fuzzy analytic hierarchy process and its renewable energy application. *Soft Comput.* **2020**, *24*, 4607–4621. [CrossRef]
89. Chakraborty, S.; Zavadskas, E.K. Applications of WASPAS method in manufacturing decision making. *Informatica* **2014**, *25*, 1–20. [CrossRef]
90. Rudnik, K.; Bocewicz, G.; Kucińska-Landwójtowicz, A.; Czabak-Górska, I.D. Ordered fuzzy WASPAS method for selection of improvement projects. *Expert Syst. Appl.* **2021**, *169*, 114471. [CrossRef]
91. Keshavarz Ghorabaee, M.; Zavadskas, E.K.; Amiri, M.; Esmaeili, A. Multi-criteria evaluation of green suppliers using an extended WASPAS method with interval type-2 fuzzy sets. *J. Clean. Prod.* **2016**, *137*, 213–229. [CrossRef]

92. Bausys, R.; Kazakeviciute-Januskeviciene, G.; Cavallaro, F.; Usovaite, A. Algorithm selection for edge detection in satellite images by neutrosophic WASPAS method. *Sustainability* **2020**, *12*, 548. [CrossRef]
93. Bausys, R.; Kazakeviciute-Januskeviciene, G. Qualitative rating of lossy compression for aerial imagery by neutrosophic waspas method. *Symmetry* **2021**, *13*, 273. [CrossRef]
94. Ilbahar, E.; Kahraman, C. Retail store performance measurement using a novel interval-valued Pythagorean fuzzy WASPAS method. *J. Intell. Fuzzy Syst.* **2018**, *35*, 3835–3846. [CrossRef]
95. Ali, J.; Bashir, Z.; Rashid, T. WASPAS-based decision making methodology with unknown weight information under uncertain evaluations. *Expert Syst. Appl.* **2021**, *168*, 114143. [CrossRef]
96. Myers, L.; Sirois, M.J. Spearman Correlation Coefficients, Differences between. In *Encyclopedia of Statistical Sciences*; John Wiley & Sons: Hoboken, NJ, USA, 2004; Volume 12, ISBN 9780471667193. [CrossRef]