Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 2153940, 22 pages
https://doi.org/10.1155/2022/2153940

Research Article

A Hybrid Fuzzy AHP/VIKOR Approach to Funding Strategy Selection for Advanced Prosthetic and Orthotic Medical Devices in Low-Income Countries: A Case of Pakistan

Irfan Ahmed,[1] **Bo Feng**,[2,3] **Daud Abdul**,[1] **and Junwen Feng**[1]

[1]*School of Economics and Management, Nanjing University of Science and Technology, Nanjing 210094, China*
[2]*School of Intellectual Property, Nanjing University of Science and Technology, Nanjing 210094, China*
[3]*Management School, Nanjing Audit University Jinshen College, Nanjing 210023, China*

Correspondence should be addressed to Junwen Feng; fengjunwen8@mail.njust.edu.cn

Received 28 June 2022; Revised 5 August 2022; Accepted 26 August 2022; Published 13 October 2022

Academic Editor: Sang-Bing Tsai

In the context of advanced prosthetic and orthotic medical devices, funding is a major challenge, especially in low-income countries. This research aims to investigate the best funding solution for such medical devices to offer disabled people a better quality of life and improve their health and economic situation. This is the first time such methods are being used in a study based on related research involving a fuzzy analytic hierarchy process (FAHP)/VIekriterijumsko KOmpromisno Rangiranje (VIKOR) model to find the best funding source. A survey questionnaire created by the author and completed by Pakistan subject experts was used to analyze data via a weightage value ranking system as an assessment tool. Prioritization of funding alternatives was based on main criteria and subcriteria. Limitations include sample number of study participants, amount of data collected, number of models used, and time constraints. Potential funding sources were ranked based on a VIKOR weightage value model using a hybrid decision-making process that showed results as "private insurance" having a weightage value of (0.1956) as being the best funding source since they are having the minimum weightage and then next from best to least they were "need-based" with a weightage value of (0.2510), "self-pay" with a weightage value of (0.7970), and finally "government-based" having a weightage value of (0.9636). Implications of this study conclude that the proposed model efficiently finds the best funding sources for advanced prosthetic and orthotic (P&O) medical devices in low-income countries. Executing this model in low-income countries such as Pakistan can help solve P&O medical device coverage challenges and offer disabled people better opportunities to work and contribute to their quality of life and economy.

1. Introduction

In today's world, many disabled people are in need of advanced prosthetic and orthotic (P&O) medical devices. Many live in low-income countries. In those regions which faced huge financial challenges, there is a problem in finding funding to cover P&O medical device costs. Herein lies the problem that needs the help of research to find a financial funding source solution. Healthcare policymakers usually debate and make decisions based on the efficacy and efficiency of research related to health technologies that concentrate on clinical interventions and medicines [1]. Today's healthcare systems are becoming an important part of a country's sustainable economic growth; according to the World Health Organization, this has made it a major key player in determining a country's economic strength and financial well-being.

Nowadays, many countries have regulatory authorities to facilitate the process of medical device validation for public use. For example, the American Food and Drug Administration 2019 identified whether an innovative product satisfies the definition of being considered a medical device. In its Code of Federal Regulations—Title 21-2022 Part 3, medical devices are covered in their entirety [2]. Medical specialists such as physicians, surgeons, and various other healthcare professionals working in the fields of radiology, anesthesiology, general surgery, medicine, and orthopedics determine medical device classification based on their scope of practice. Medical devices differ in terms of medical discipline, the complexity of technology, context, efficacy, and efficiency of use, and for which medical condition it is designed to help treat. There are wide varieties of technologies it can include, such as those that offer basic applications such as scalpels and bandages to far more technologically advanced devices, which include implantable defibrillators and deep-brain stimulators [3].

In the world of advanced P&O medical devices, prosthetists and orthotists are healthcare professionals who evaluate, design, develop, and deliver artificial computer legs, hands, and braces to amputees who are people missing a limb, a part of a limb, or multiple limbs. They also facilitate other physically disabled individuals in need of assistive support. The cost of supplying a microprocessor-controlled advanced P&O medical device is usually quite high, which creates huge financial funding challenges. Many disabled people are left helpless in trying to pay for a device. Those that are able to supply in the short-term also need to consider how to pay for associated costs in the long term, such as ongoing maintenance and future replacements [4]. Difficulties include developing a decision-making process that manages all data and criteria while showing how each criterion is relevant; in other words, multiple-criteria decision-making (MCDM) is a process for this research. Multiple-criteria decision-making (MCDM) is frequently employed nowadays when trying to solve real-life situations [5]. Many fields such as finance, information technology, renewable energy, and medical diagnostics use MCDM as a great approach to solving multiple-criteria problems [6]. It helps to form the foundation for selecting, sorting, prioritizing materials, and meaningful assessment [7, 8]. Many complex problems benefit from using MCDM, especially those focusing on selecting the best alternative. Choosing the best alternative considers many aspects of a problem; therefore, many real-life problems involve a group of decision-makers [9]. MCDM concept theory is based on the understanding that two reference points are used, i.e., one being a positive ideal solution (PIS) while the other is a negative one, with both being used as benchmarks [10]. In a situation, decisions made by each DM (usually in the form of an individual decision matrix) are often aggregated to form a collective decision (also in the form of a collective decision matrix). This collective decision is the starting point for ranking the alternatives or selecting the best choice [11].

As this research is complex, the following questions need to be answered:

What is a good method for selecting the best funding choice?

Will using a hybrid MCDM be the solution needed to solve the advanced P&O medical device funding problem in low-income countries?

These are the questions that this study poses in order to find the most suitable answers for the best possible research outcomes.

In order to conduct a comprehensive evaluation of funding sources, a model that integrates the fuzzy analytical hierarchy process or FAHP with the VIKOR method is designed to determine weighting values for establishing the importance of the main criteria and subcriteria. The higher the weighting value, the more likely the funding alternative will be a possible choice as a source over those that have a lesser weighting value [12]. Research findings from previous studies are highly recommended for comparison purposes; however, to date, no work has been done similar to this research. However, other studies have been completed with a focus on prosthetic and orthotic innovation in various economies.

The structure of the paper is broken down into sections that concern litrature review with preliminaries of the methods applied and covers financial source appraisal criterion. This then leads to the methodology of our research with analysis and results presented in our findings, and lastly, there is a conclusion to the overall project.

2. Literature Review

A systematic review of existing literature is carried out online using keywords and phrases associated with finance and health economic issues encountered in the P&O industry. Some literature reviewed showed that others are breaking ground in P&O research. For example, Clarke et al. [13] conducted a systematic review that identified evidence gaps, critical method design, and reporting issues in the P&O field relating to policy and investment decisions. Shahabi et al. [14] used a hierarchal analytic process that explored several policy solutions for incorporating P&O services into the Iranian Health Benefits Package to try and curb the financial burdens of P&O users, especially in vulnerable groups. Furthermore, Harkins et al. [15] did a comprehensive review of literature based on P&O medical devices in the developing world, whereby he identified specific challenging factors in these areas. MCDM has the capability to contribute to a transparent and rational process of prioritization. Priority matter can be very challenging when it comes to looking at it from different medical perspectives [16]. MCDM is suitable for benchmarking numerous applications such as those used in the computer and information technology sector. Many of these techniques have advantages and disadvantages [17]. Prioritization is considered challenging from different kinds of medical perspectives [18]. It has been proven, however, that MCDM has the potential to contribute to fair, transparent, and rational processes. In any of these types of MCDM cases, there needs to exist a definition of substantial terms, for example, "alternatives," "the criteria," and "decision or evaluation matrix" [19].

Although in these previous studies, the cost is identified as a factor for consideration and hierarchal process as a potential methodology, we found no research existing at the time of the writing of this paper pertaining to the methodological design of a model for funding strategy selection of advanced P&O medical devices. It is therefore ascertained that this paper considers addressing a gap in research and, as such, proposes an integrated fuzzy logic-based model to be designed to help find the best funding source alternatives.

While others, such as Işik and Arslan [20] incorporated fuzzy logic to design ultrasonic therapy and medical imaging [21], and this is the first time a model such as ours is used for P&O research which makes it a true novelty concept in its field. Our novel study is unique in nature as it is designed using a mixed-methods integrative strategy for determining the best choice of advanced P&O medical device funding alternatives. It includes, more specifically, FAHP and VIKOR integration methods that are chosen as best research methods because AHP employs fuzzy integration while determining fuzzy criteria and subcriteria weightage values, which is proven effective in hierarchical structure situations [22]. VIKOR is also proven useful in ranking strategies, especially for those that consider subcriteria [23].

The processes of analysis and findings in this study involve techniques for checking and confirming the validity. These include information gatherings from peer reviews, expert opinions, triangulation of data, and numerous professional collaborations in regard to the subject matter. Google Scholar was utilized to find relevant citations that were searched in health economic articles that met with inclusion criteria. Other online articles that have not been included in existing large traditional databases were also searched. During the early stage of our research process, an independent reviewer extracted and appraised data related to the subject matter, and a second researcher confirmed data accuracy. A final review was then performed by a third person to ensure the overall subject matter and data integrity.

A total of 16 subject experts agreed to participate in this research by giving consent to complete a survey questionnaire. Data from this survey were extrapolated and analyzed, and an integrated FAHP/VIKOR model was designed to determine the selected main criteria and subcriteria weightage values. The use of FAHP combined with VIKOR modeling makes for an effective MCDM technique; hence, it is the reason for its application here. Our research process establishes the research objectives as it gathers relevant criteria while it considers best choice funding source alternatives.

2.1. The FAHP Method. The FAHP method was developed in 1965 by professor Zadeh, who developed fuzzy logic mathematics, which has applications in many subjects, including health care [24]. AHP offers a way of better understanding the uncertainty of estimates and actual sums with an error margin in research studies. MCDM techniques like the AHP evolved into fuzzy logic over time, creating the conception of FAHP [25].

Our research uses the FAHP method as this approach has inbuilt checks and balances that ensure logically consistent funding source solutions which are found when the relative importance of specific criteria in the process has weightage values assigned to them [26]. For this study, four selective criteria and 16 subcriteria were identified to prioritize in order to find the best outcome to address the advanced P&O medical device funding problem [27]. Decision-making that involves health care mostly requires sound judgment models. Those equipped to deal with fuzziness or ambiguity are seen as the best choices to design mainly because fuzziness and ambiguity are usually present in the healthcare finance sector, especially in low-income countries. Therefore, it is common for decision-makers to analyze facts and figures to try and offer the best choices. Usually, the traditional AHP selects arbitrary values in a pairwise comparison, which creates doubt and uncertainty, which may not be good for consensus. Because of fuzzy logic's ability to consider decision-makers' attitudes from subjective values, membership functions are usually characterized by triangular fuzzy numbers recommended for assessing preference ratings rather than a conventional numerical equivalence approach [28]. An example of this is shown in the following linguistic scales in Table 1.

Table 1: Linguistic scale for pairwise comparison criteria.

Fuzzy value	Subjective description	Fuzzy scale number
1	Equal	(1, 1, 1)
2	Weak advantage	(1, 2, 3)
3	Not bad	(2, 3, 4)
4	Preferable	(3, 4, 5)
5	Good	(4, 5, 6)
6	Fairly good	(5, 6, 7)
7	Very good	(6, 7, 8)
8	Absolute	(7, 8, 9)
9	Perfect	(8, 9, 10)

In his study, Saaty (1994) proposed a fuzzy AHP approach to determine a hierarchical framework, fuzzy sets, and the judgment matrix by building the triangular fuzzy numbers and finalizing the weights, which were introduced as the main steps that needed to be followed in the FAHP [20]. This approach is useful in our study as it substantiates an evidence-based approach for the implementation of a subjective linguistic scale for pairwise comparisons between different proposed elements. Triangular fuzzy numbers represent values for each linguistic term in consideration as approximate values.

$$\mu_{(A)}(x) = \left\{ \begin{array}{cc} 0 & \\ x - a_1/a_2 - a_1 & x \angle a_1 \\ & a_1 \le x \le a_2 \\ a_3 - x/a_3 - a_2 & a_2 \le x \le a_3 \\ 0 & x > a_2 \end{array} \right\}. \quad (1)$$

The FAHP technique of Chang was used to simplify analysis steps [29]. This method of determining the extent of anything is known as "extent analysis" and considers an object set as: $A = (a_1, a_2..., a_n)$ and $B = (b_1, b_2..., b_m)$ as a goal set. Each component is given its own consideration, such as "g_i" presents possible goals; therefore, for each element, the m extent analysis numbers are as follows:

$$N_{gi}^1, N_{gi}^2, \ldots, N_{gi}^m, i = 1, 2, \ldots, n, \tag{2}$$

where N_{gi}^j $(j = 1, 2, \ldots, m.)$ is considered as triangular fuzzy numbers.

Chang executed his strategy using the following step process:

Step 1. Equation is used to calculate the fuzzy value for the i[th] item as follows:

$$S_i = \sum_{j=1}^{m} N_{gi}^j * \left[\sum_{i=1}^{n}\sum_{j=1}^{m} N_{gi}^j\right]^{-1}, \tag{3}$$

where $\sum_{j=1}^{m} N_{gi}^j$ is given as follows:

$$N_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right). \tag{4}$$

$[\sum_{\mathbf{i}=1}^{\mathbf{n}} \sum_{\mathbf{j}=1}^{\mathbf{m}} \mathbf{N}_{\mathbf{gi}}^{\mathbf{j}}]^{-1}$ is given as follows:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} N_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right). \tag{5}$$

The inverse of the values in equation (5) is then computed as

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} N_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_{j=1}^{m} u_j}, \frac{1}{\sum_{j=1}^{m} m_j}, \frac{1}{\sum_{j=1}^{m} l_j}\right). \tag{6}$$

Step 2. The degree of possibility of $N_2 = (l_2, m_2, u_2) \geq N_1 = (l_1, m_1, u_1)$ is considered as

$$V(N_2 \geq N_1) = \sup[\min(\mu_{N1}(x), \mu_{N2}(y))]. \tag{7}$$

It is always stated as follows:

$$V(N_2 \geq N_1 = hgt)(N_1 \cap N_2) = \mu_{N2}(d) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_2 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases}, \tag{8}$$

where d presents the highest intersection point between μ_{N1} and μ_{N2}.

V $(N_1 \geq N_2)$ and V $(N_2 \geq N_1)$ require comparing N_2 and N_1.

Step 3. The probability that a convex fuzzy number is greater than k convex fuzzy numbers. $Ni(i = 1, 2, \ldots, k)$ is as follows:

$$V(N \geq N_1, N_2, \ldots, N_k) = V[(N \geq N_1) \text{ and } (N \geq N_2) \text{ and} \ldots \text{and} (N \geq N_k)] = \min(N \geq N_i), i = 1, 2, \ldots, k. \tag{9}$$

If $d'(A_i) = \min V(S_i \geq S_k)$, for $k = 1, 2, \ldots, n; k \neq i$, the weight vector is represented as follows:

$$O' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T, \tag{10}$$

where $A_i (i = 1, 2, \ldots, n)$.

Step 4. The normalized weight vectors after the normalization technique are as follows:

$$O' = (d(A_1), d(A_2), \ldots, d(A_n))^T, \tag{11}$$

where O is not considered as a fuzzy number anymore.

2.2. VIKOR Method. The VIKOR method is a ranking method used to optimize a multiresponse process. The compromising nature of VIKOR's model ranking has specific indexes based on the "closeness" to an "ideal" solution. This technique deals with a set of "alternatives" with conflicting criteria and is the core of what VIKOR represents. In scenarios where decision-makers face challenges, identifying preferences during the early stages of system design makes VIKOR a useful tool in multicriteria decision-making. The acquired average solution that a VIKOR model offers is a maximum "group utility," otherwise known as "majority," and a minimum value of the individual is regarded as being the "opponent" [30]. Any compromised solutions provide the framework for negotiations which can then be incorporated into a decision-maker's weight preferences as a base point that allows it to be strategically customized for a wide range of scenarios.

The VIKOR technique is chosen for this study because it has gained much popularity over the past two decades especially because it uses fuzzy set theory when representing complicated systems. It is selected as a part of our model design as it is determined to be a good way to use extrapolated data from surveys conducted concerning advanced prosthetic and orthotic medical devices and using multi-decision-making criteria for funding source selection for low-income countries. There are steps for developing and normalizing the decision matrix, ideal positive and negative solution determination, and utility/index value calculation.

Step 5. An example of decision matrix development is as follows:

$$D = \begin{array}{c} \\ A_1 \\ \vdots \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} C_{x_1} \cdots C_{x_3} \cdots C_{x_n} \\ \begin{bmatrix} x_{11} & \cdots & x_{13} & \cdots & x_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{31} & \cdots & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & \cdots & x_{m3} & \cdots & x_{mn} \end{bmatrix} \end{array}. \quad (12)$$

As presented, decision matrix D, while "j^{th}" criteria are "C_{xj}" and "i^{th}" alternative is "A_i." It also includes $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$, whereas for individual performance, it considers each alternative source as "x_{ij}."

Step 6. The normalized decision matrix as follows:

$$Q = \left[q_{ij}\right]_{m\times n}, \quad (13)$$

where $q = x_{ij}/\sqrt{\sum_{i=1}^{n} x_{ij}^2}$, $(i = 1, 2, \ldots m; j = 1, 2, \ldots n;$ and $x_{ij})$ is the value of alternative concerning the j^{th} criterion.

Step 7. The step focuses on positive and negative ideal solution and expresses A^* as positive and A as negative, which are determined as follows:

$$A^* = \left\{ \begin{array}{c} \left(\max p_{ij}, \text{for beneficial criteria}\,(B)\right) \\ i = (1, 2, \ldots, m) \\ \left(\min p_{ij}, \text{for nonbeneficial criteria}\,(NB)\right) \end{array} \right\} = \left\{q_1^*, q_2^*, q_j^*, \ldots, q_n^*\right\}.$$

$$A^* = \left\{ \begin{array}{c} \left(\min p_{ij}, \text{for beneficial criteria}\,(B)\right) \\ i = (1, 2, \ldots, m) \\ \left(\max p_{ij}, \text{for nonbeneficial criteria}\,(NB)\right) \end{array} \right\} = \left\{q_1^-, q_2^-, q_j^-, \ldots, q_n^-\right\}. \quad (14)$$

Step 8. Now, we need to calculate the utility measure V_{Si} and regret V_{Ri}; the following expressions are used to determine these values for each alternative:

$$V_{Si} = \sum_{i=1}^{n} w_j \frac{\left(q_j^* - q_{ij}\right)}{\left(q_j^* - q_j^-\right)},$$

$$V_{Si} = \max_j \left[w_j \frac{\left(q_j^* - q_{ij}\right)}{\left(q_j^* - q_j^-\right)} \right], \quad (15)$$

where w_j represents the weights of criteria.

Step 9. Now, we need to calculate the index value Q_i as follows:

$$Q_i = v\left[\frac{V_{Si} - V_{Si}^*}{V_{Si}^- - V_{Si}^*}\right] + (1 + v)\left[\frac{V_{Ri} - V_{Ri}^*}{V_{Ri}^- - V_{Ri}^*}\right], \quad (16)$$

where Q_i represents the i^{th} alternative value $(i = 1, 2, \ldots, m).v_{si}^* = min\, V_{SI}, V_{SI}^- = max V_{Si}, V_{Ri}^* = min V_{Ri}, V_{Ri}^- = max V_{Ri},$ and v is indicated as the weight of maximum group utility, and it is generally set to $0:5$.

Step 10. Ranks the order as it identifies the importance of alternatives, with the smaller weightage value being the least good solution, as high rankings are the better options to choose.

3. The Appraisal Funding Alternatives

The four essential health economic potential funding alternatives for advanced P&O medical devices in recent years include "self-pay," "government pay", "private insurance," and "government need-based." A universal healthcare system in a low-income country comprises basic primary healthcare units, rural health centers, and secondary and tertiary healthcare centers [31]. Most of the programs and responsibilities of the Health Ministry are usually transferred from the federal level down to the provincial level health departments. Health systems need to be better structured to adequately serve the needs of low-income countries in an effective, efficient, and equitable manner. Unfortunately, this is not always the case because political, cultural, socio-economical, and physical infrastructure factors can influence health behaviors. Therefore, policymakers need to comprehend which drivers are impacting health-seeking behaviors as this can seriously impact their healthcare systems [32].

3.1. Self-Pay Funding. Self-pay funding, also known as "out-of-pocket expense," is the earliest method used in health care and can be defined as full payment for a healthcare service. For this study, self-pay is considered as making 100% payment for advanced P&O medical devices. According to the World Health Organization, this is the most widely used source of funding in health economics, where a vast number of people living in low-income countries spend a huge portion of their living expenses on basic health needs [33]. This funding source is among health economic most identifiable financial funding.

3.2. Government Funding. Government funding, also known as Universal Health Coverage (UHC) is becoming more of the healthcare fabric in recent years as this type of funding promises to deliver highly needed health care to individuals, families, and communities. Prioritization of advanced P&O medical devices based on predefined parameters such as economic, clinical, and socio-political aspects is one of the advantages of having government funding [34].

3.3. Private Health Insurance. Health insurance provided by a private company is a system whereby a person pays a set

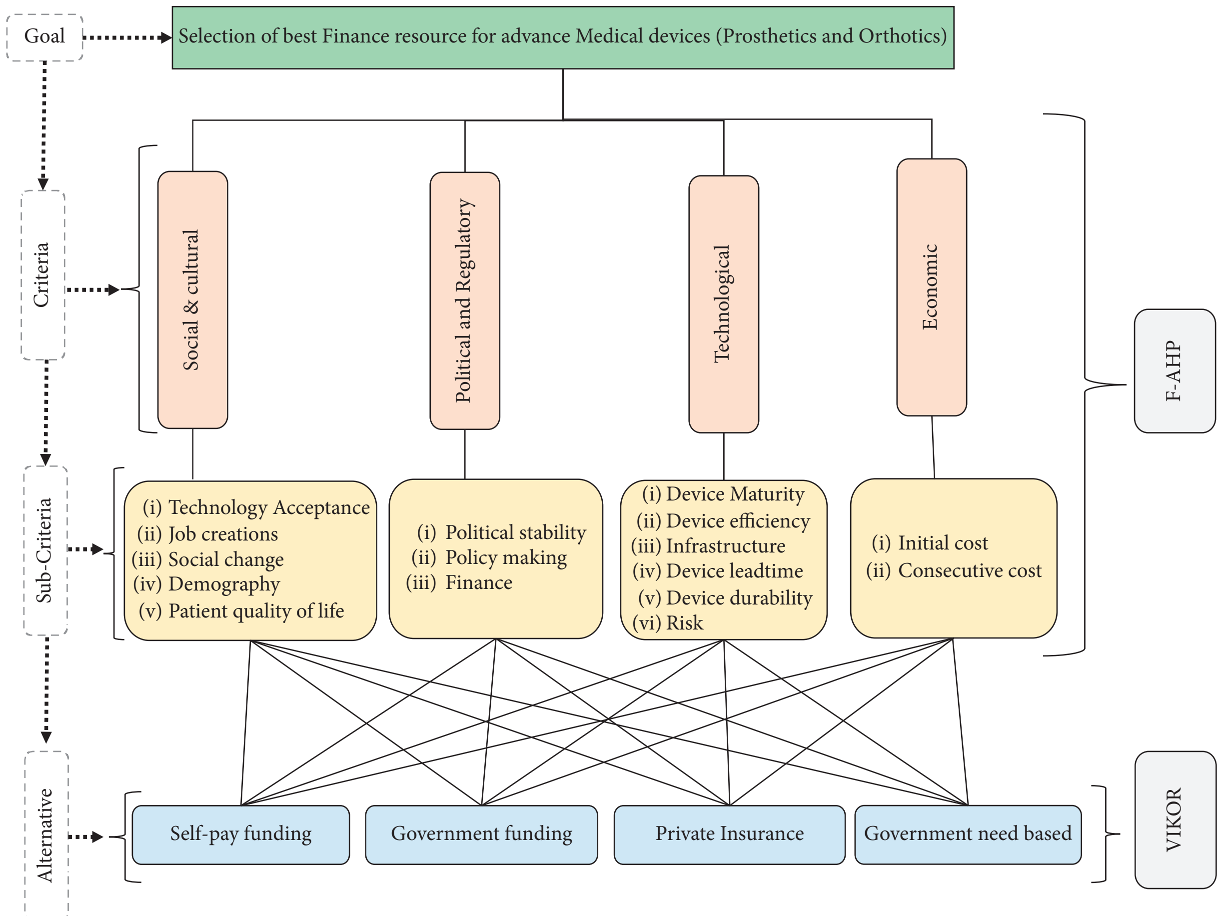

Figure 1: The hierarchy structure of the study.

premium to a health insurance company, thus ensuring that financial risks are shared and funds are pooled, which has the effect of reducing financial burdens and/or eliminating direct payments from the insurer.

3.4. Government Need-Based Funding. Government need-based funding is designed to provide all populations with the interventions they need at a cost level that would protect them from financial hardships.

4. The Appraisal Funding Criteria

There are multiple factors that are needed to be considered when developing and implementing appropriate advanced P&O medical device funding sources. According to Poonekar, a list of predominant factors is identified [35]. Based on this research, appraisal criteria for funding sources for our study are categorized into four main criteria and 16 subcriteria, such as social and cultural, political and regulatory, technological, and economic, which are the areas of main concern. Figure 1 presents our framework for the selection of the best financial funding sources for advanced P&O medical devices formulated for this study.

The framework of this research shows individual factors that are ranked according to their importance within the industry as the researcher explores ahead for the future. It is important for developing countries that political factors such as political stability, monitoring of legislation, restrictions, and conditions should be carefully analyzed along with various other policies that involve integration and taxes [36].

4.1. Social/Cultural Factors

4.1.1. Technology Acceptance. A variety of policy considerations should be taken into account while accepting technology [37]. These can be applied to advanced P&O medical devices at different levels in existing healthcare systems, such as manufacturing and technical expertise. Government support for research and development can be affected by technological factors such as the use of technology in discovering new devices, which can also play a part in influencing an economy [38].

4.1.2. Job Creation. Any successful system of health care that guarantees the benefit of coverage for advanced P&O medical devices will generate demand for jobs in the country, such as clinicians, engineers, manufacturers, and business professionals in different levels of government, semigovernments, nongovernment, and private sectors.

4.1.3. Social Change. The social and cultural environment has many factors that influence it, including demographic location, education, employment rate, and population income [35, 39]. The evaluation of the sociological aspect focuses on the extent to which it adequately takes into account these main factors as the greater the net social benefits of a project designed, the higher the rank [15].

4.1.4. Demography. Cultural and climatic factors can influence a region's health economic system [35, 40]. In manpower, for example, demographics can be evaluated to understand the people and their workers' capability in knowledge, wisdom, know-how, and character to implement a public project according to its plan. The greater ability of people engagement makes way for a higher ranking.

4.1.5. Quality of Life. An individual's quality of life is mainly focused on emotional, psychological, religious, activities of daily living (ADLs), vocational and nonvocational factors, medical device appropriateness, giving confidence and comfort, being lightweight, cosmetic, and psychosocially acceptable to the individual [35, 41, 42].

4.2. Political/Regulatory Factors

4.2.1. Political Stability. Political stability is necessary in order to promote global economic growth and overall well-being throughout the world. Being able to have a progressive government can do much to eradicate social inequalities, especially where healthcare is concerned. Therefore, it can be safe to say that public health is based upon the foundation of social justice [43, 44].

Making healthcare policy requires understanding the relationship between political stability and economic prosperity. Any unstable political setting for a country can mean deepening public debt, high inflation rates, and economic demise. Such is the case of low-income countries, which have not shown any economic growth stability for numerous years [45]. Many of these regions have remained a victim of political instability mostly due to civil and military regimes preventing institutions from reaching their full potential [46, 47]. The economy has suffered harshly as a result. This shows how political instability reduces economic growth and political stability increases it [48].

4.2.2. Policymaking. Policymaking in health care is a crucial part of a country's economic framework [49]. Differing perspectives among policymakers can negatively impact healthcare budgets, which can halt the funding and delivery of advanced P&O medical devices. However, sound macro policy development, evaluation, and implementation can positively impact health care, such as opening up new opportunities for funding sources and prioritizing criteria that can encourage potential funding options.

A country whose government and insurance organizations are able to come together through effective policymaking processes [50] that consider such important areas as types of advanced P&O medical devices to cover various age groups, disabilities, etc. has the potential to develop high-quality, sustainable healthcare benefits packages for its people [51].

4.2.3. Finance. Economic factors in finance can be a lifeline for optimizing a country's healthcare system [52]. The economic feasibility of medical equipment, which may considerably add to a country's gross domestic product, can be an essential aspect. Both public and private sectors can influence healthcare budgets; therefore, it is beneficial that financial analyses should be done to determine the best funding alternatives [53].

4.3. Technical Factors. The main factors considered in evaluating a project from a technical point of view include but are not limited to the availability of skill sets, materials, infrastructure for technology, machinery, and equipment. The subcriteria for this include the following.

4.3.1. Device Maturity. Device maturity consists of factors such as a device made locally and by local people and is technically functional [54]. The device's level or degree of complexity usually indicates how far-reaching its technology spreads and can range from national to global [55].

4.3.2. Device Efficiency. Device efficiency depends on the ability of trained professionals to properly assess and evaluate outcome measures [56] for it is their knowledge, expertise, and ingenuity that makes an invention successful for those who will avail of and seek benefit from it [57].

4.3.3. Infrastructure. Industrialized countries worldwide can export advanced P&O medical devices for disabled persons living in low-income countries. However, the situation becomes difficult when these devices need maintenance, and many low-income areas are not able to provide them [58, 59]. Lifestyles in these challenging environments also make advanced P&O medical devices difficult to use. In many cases, therefore, it is more common for ancient, more primitive indigenous devices to be used which can in the long run create further issues and more complex problems that need to be addressed.

4.3.4. Device Lead Times. Device lead times can be an uphill battle that involves an advanced P&O medical device's development, implementation, and continual evolution [60]. It may include input from many areas of expertise such as healthcare professionals, engineers, health economists, financial analysts, and industrialist investors.

4.3.5. Device Durability. Device durability focuses on medical device technologies which include but are not limited to advanced medical devices [61], i.e., P&O

microprocessor applications, artificial intelligence (AI), cloud computing, and/or flexible electronics integration [62].

4.3.6. Risk. This principle addresses the all-risk including financial risk associated with one-time funding for advanced P&O medical devices and/or the cost of developing these device technologies continually [63]. The continuity of patient care becomes a long-term component of a nation's healthcare package rather than being foreign funding at a one-time expense. Risks such as these can have a negative effect on current policies and technologies already in place.

4.4. Economic Factors

4.4.1. Initial Cost. The initial cost is also known as "technology costs "and is associated with the purchasing of machinery and other technical equipment along with setup costs associated with P&O medical devices in healthcare facilities. It can also include costs pertaining to connection to local healthcare networks, manufacturing, and engineering design. When a patient first needs a medical device, this amount is also considered to be an initial cost.

4.4.2. Consecutive Cost. This is a reoccurrence continuity of patient care cost because these patients will need devices for the rest of their lives. It includes annual maintenance, repair costs, and new devices after a reasonable amount of time (e.g., 3 to 5 years).

4.5. The Proposed Integrated FAHP/VIKOR Approach. Initially, subject experts were identified and a survey questionnaire was developed from previous P&O research material. Data obtained from the survey were collected with perspectives from economists, and Pakistan's healthcare department and clinicians shared to ensure an appropriate level of subject broadness and variation with the research goal of achieving the most robust outcome and limiting bias.

Advanced P&O medical devices are costly and can put a financial strain on any healthcare system, whether it is universal health coverage, private insurance, or self-pay. Assessing the funding potential for which to finance long-term advanced P&O medical devices is a very complex process. It relies on the accuracy of many determining factors combined with a framework for evaluation that needs to be focused on constantly changing costs due to the nature of these rapidly evolving technologies, continuity of lifelong service for the device recipient, i.e., the patient, and constant patient care follow-up requirements.

4.6. Quantification of the Process. This study covers surveys and data accumulated using a linguistic approach. Qualitative data are converted into quantitative data by assigning weightage values used in designing a decision matrix. Weightage values are assigned using the FAHP approach with data collected from subject experts from Pakistan's government, private sector, economists and financial experts, revenue tax collectors, policymakers, clinicians, and caregivers who participated by offering insightful knowledge, different views, and professional opinions, with criteria and subcriteria to assist in determining best funding source alternative.

Table 2: Alternative rating with subjective values.

Linguistic variable	Very low	Low	Moderate	High	Very high
LVs	VL	L	M	H	VH
Assigned values	0.00	0.25	0.50	0.75	1.00

The FAHP effectively accommodates the linguistic scale of criteria and subcriteria for a pairwise comparison matrix because it is the basic foundation to build diversified, value-added, and unbiased research. It is used as an effective method for finding weighting values within a diversified group of subject experts. The basic understanding that different experts have can be strong and sometimes very opposing in their views on research topics which can significantly influence weightage points. Due diligence and due care of data are necessary for these situations so as to ensure that criteria and subcriteria final weightage values are as accurate as possible to ensure group intelligence.

4.7. The Comprehensive Method

Step 11. Understand the value of financial sources in terms of all subcriteria.

A comprehensive need for future funding of advanced P&O medical devices was analyzed for this research study to understand the various social, political, technical, and economic aspects that may be used in healthcare policy. The qualitative value of subcriteria is assigned a value as the funding source for alternative ranking along with a description of a 5-point subjective scale as shown in Table 2.

Step 12. Normalize the values.

The results of the surveys were used to collect qualitative subcriteria data. Then, the data were transformed into an LV-assigned number with average values calculated. Lastly, these values were normalized using equation (2) which normalized the quantitative data of subcriteria (2).

Step 13. Use the VIKOR method to execute the procedure.

After the data are normalized, the final values of each option are determined using the VIKOR technique. The framework and stages of the proposed model are presented in Figure 2.

5. Case Study: Pakistan

This case study looks at finding best funding source alternatives for advanced P&O medical devices in low-income countries. According to its household income per capita, Pakistan is a lower middle-income country, which makes it suitable for this case study [64]. The region of main focus research is Sindh province, Pakistan which is a region with many health and economic challenges. Unfortunately, due to

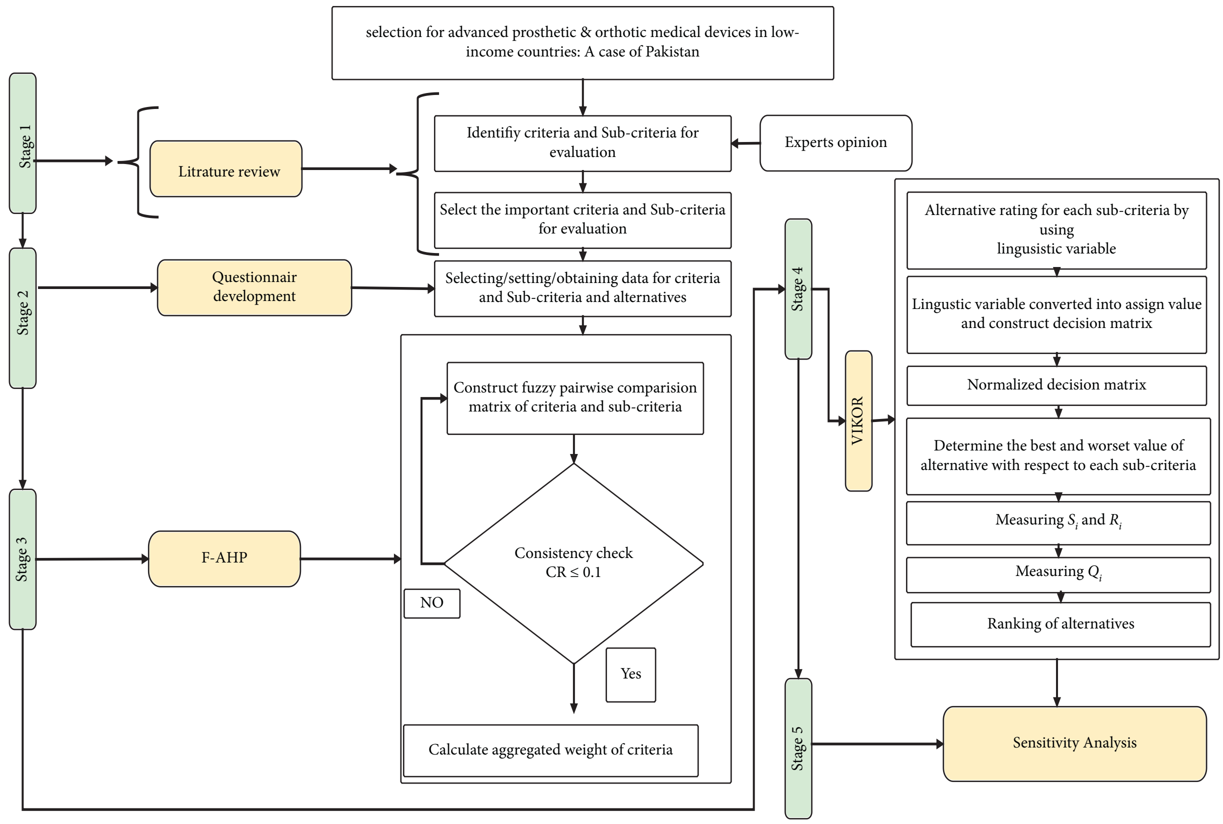

Figure 2: The framework and stages of the proposed model.

poor income levels, there is a need for this area to find viable funding alternatives to cover the costs of providing advanced P&O medical devices to its disabled community. With the development of Pakistan's Empowerment of Persons with Disabilities Act 2018 [65], nowhere does it specify any guaranteed funding for advanced P&O medical devices. In addition to this, there is a significant income gap between Sindh's urban and rural economies. These two factors create urgency for a health economic analysis to be carried out so as to identify funding trends in Pakistan's healthcare system so that actions for change can be initiated and policies improved for payment coverage of advanced P&O medical devices for the future.

6. Case Study Analysis

6.1. Advanced P&O Medical Device Cost. Subject experts identified a list of advanced P&O medical devices for amputees and other physically disabled people. We discuss the current factors relating to healthcare policy, estimation of people in Sindh province in need of P&O medical device funding, medical device regulators, country's advanced technology, microprocessor technology capability, supply chain, and regulation for access from other Pakistan provinces (e.g., Baluchistan, Punjab, Gilgit-Baltistan, Azad Kashmir, and Khyber Pakhtunkhwa) as well as Islamabad, the country's government capital. Pakistan is an open market for supplying imports from different countries. One supplier who imports advanced P&O medical devices from different parts of the world such as the USA, EU, and China, was identified. The average cost estimation of current advanced P&O medical devices was sorted out and tabulated in US dollars. The tentative costs of advanced P&O medical devices range from 10.5 lakh to 45 lakh ($^{\$}$1500–$^{\$}$25,000). Urban and rural areas have different costs of living and purchasing power due to their different economic structure; for instance, urban areas are mostly comprised of service industry whereas rural areas are mostly made up of agricultural industry. In June 2019, Pakistan's per capita yearly household income was 587.069 USD [66].

6.2. Survey Design. The survey questionnaire design focused on factors identified, evaluated, and discussed with subject experts within the related literature scope, purpose, and role for current studies. It was comprised of subject matter relating to pairwise comparison, factors vs. alternative solutions and benefits/nonbenefit importance. All collective factors of Sindh, Pakistan's health economic policy research and the best financial source for advanced P&O medical devices were grouped into criteria and subcriteria based on the specified scope of study [13, 15, 35, 37, 40]. The correlation coefficient between criteria/subcriteria was analyzed with results obtained with high-value numbers; therefore, it was decided to use a social/cultural, political/regulatory, technology, and economic framework instead. The expert's demographic information is presented in Table [16].

Table 3: Overall weight of subcriteria.

Main Criteria	Weight	Sub-criteria	Weight	Overall weight
C1	0.20143	C11	0.1530	0.03082
		C12	0.1959	0.03946
		C13	0.1795	0.03616
		C14	0.2135	0.04301
		C15	0.2582	0.05201
C2	0.20512	C21	0.3188	0.06539
		C22	0.3363	0.06898
		C23	0.3449	0.07075
C3	0.30386	C31	0.1250	0.03798
		C32	0.1431	0.04348
		C33	0.1628	0.04947
		C34	0.1625	0.04938
		C35	0.1801	0.05473
		C36	0.2265	0.06882
C4	0.28958	C41	0.2878	0.08334
		C42	0.7122	0.20624

Table 4: Main Criteria results.

Criteria	C1	C2	C3	C4
Weight	0.20143	0.20512	0.30386	0.28958

6.3. Application of the Proposed Integrated FAHP/VIKOR Model. The study framework criteria/subcriteria were translated into comprehensive questions for FAHP and VIKOR modeling. FAHP was addressed using a criteria/subcriterion fuzzy pairwise comparison matrix which provided solutions by designating numerical positions to other criteria/subcriteria factors in comparison, as shown in Table 3. The same procedure was followed for the sub-criteria. Each one was included by a priority vector which identified importance to other criteria in the framework component for the parent level. It facilitated the calculation of normalized value with the eigenvector of the matrix, which is a priority vector. This offers consistency in points for the comparison matrix, and Table 4 presents this result for the main criteria. The weight model was proposed as a pairwise comparison matrix outcome for the final weights of criteria by designating subjective variables into a quantifiable solution. Fuzzy logic was introduced to variables in Microsoft Excel based on a 1–9 linguistic scale using subject expert experience values, as shown in Table 1.

The VIKOR model was introduced to offer solutions between criteria/subcriteria to an alternative financial solution. Subjective characteristics such as very low, low, moderate, high, and very high were used to score the comparisons and then designated the weightage of 0.0, 0.25, 0.50, 0.75, and 1.00 as presented in Table 2. Its purpose was to offer the best selection choice in the framework.

The FAHP model using initial comparison matrices of right and left criteria are analyzed by subject experts. Table 4 presents the findings of the pairwise comparison matrix for the major criteria, followed by the results of the fuzzy survey for the FAHP model main criteria weightage, which are used to construct Table 2 for four financial alternative funding sources for advanced P&O medical devices.

Subject experts identified criteria for comparison matrix components, and the FAHP model facilitated a fuzzy pairwise comparison matrix at each level and numerical value positions of each criteria component vs. alternate component of the matrix as shown in Table 5 as follows.

Afterward, a normalized principal eigenvector was established with calculation for each comparison component known as a priority vector to identify the importance of individual components at their parent level for the purpose of point-in-time consistency of results.

Furthermore, fuzzy logic calculated the AHP pairwise comparison matrix and results of subcriteria for the purpose of getting weightage values for C1-social and cultural aspect, C2-political and regulatory aspect, C3-technological aspect, and C4-economic aspect in the respective Tables 6–9.

6.4. The Overall Value of Weights Analysis. The main criteria and subcriteria with weightage values with total weights proposed factors are presented in Table 3. The comparison matrix results demonstrate an important relationship by value between subcriteria such as recommended selective subcriteria such as social vs. patient quality of life value (0.05201), policy vs. finance value (0.07075), technology vs. risk value (0.06882), and economic vs. initial cost value (0.08334) factors which have a significant role.

The results show that the 1st criteria of "social/cultural factors" have significant importance as determined by the Pakistan subject experts selected for participation in the study. The most important of the subfactors is determined to be "Quality of Life" for patients. It focused primarily on assimilating patients into society as independent individuals. As determined by the subject experts, the next subfactor of importance was "Demography," which addresses age, race, ethnicity, gender, marital status, income, education, and employment. The experts believed that Pakistan's working people could understand and get engaged in knowledge, wisdom, know-how, and character, which was positive for the country. The 3rd subfactor was "Job Creation" which was

Table 5: Fuzzy pairwise comparison matrix.

	C1			C2			C3			C4		
C1	1	1	1	0.5333	0.7654	1.1766	0.4452	0.6010	0.9405	0.6184	0.8781	1.3161
C2	0.8499	1.3064	1.8750	1	1	1	0.4039	0.5570	0.8625	0.4619	0.6276	0.9405
C3	1.0632	1.6640	2.2462	1.1594	1.7955	2.4756	1	1	1	0.6463	0.8717	1.1766
C4	0.7598	1.1388	1.6171	1.0632	1.5935	2.1652	0.8499	1.1472	1.5474	1	1	1

Table 6: C1 A pairwise comparison matrix with subcriteria result.

	C11			C12			C13			C14			C15			Weight
C11	1	1	1	0.3938	0.5816	0.9475	0.5238	0.7147	1.0520	0.5294	0.8199	1.3499	0.4819	0.6771	1.1185	0.1530
C12	1.0554	1.7193	2.5392	1	1	1	0.6672	0.9170	1.3064	0.5755	0.7793	1.1342	0.5070	0.7518	1.2287	0.1959
C13	0.9506	1.3993	1.9090	0.7654	1.0905	1.4987	1	1	1	0.6054	0.7408	0.9238	0.4204	0.5902	0.9576	0.1795
C14	0.7408	1.2197	1.8888	0.8817	1.2831	1.7377	1.0825	1.3499	1.6518	1	1	1	0.5470	0.7654	1.1472	0.2135
C15	0.8941	1.4768	2.0750	0.8138	1.3301	1.9724	1.0443	1.6942	2.3786	0.8717	1.3064	1.8280	1	1	1	0.2582

Table 7: C2—A pairwise comparison matrix with subcriteria result.

	C21			C22			C23			Weight
C21	1	1	1	0.5713	0.8347	1.2603	0.7276	1.0000	1.4650	0.3188
C22	0.7935	1.1980	1.7505	1	1	1	0.6505	0.8562	1.1766	0.3363
C23	0.6826	1.0000	1.3743	0.8499	1.1680	1.5372	1	1	1	0.3449

important because the experts felt that if more people were able to work in Pakistan, the economy would become more stable. The 4th subcriteria of "Social Change" was determined in this order on the list as the experts felt it could lead to the expansion of Pakistan's society, and this would lead to more innovation in technology which could help the country's economy grow and prosper. Lastly, the 5th of the subfactors of "Technology Acceptance" was considered the lowest on the list of importance by the experts as they believed that Pakistan's entire country's infrastructure was outdated and needed a major overhaul.

The results regarding the main criteria of "Political/Regulatory" factors were considered to be of secondary importance in this study as determined by the experts. The most important of the subfactors associated with this criterion was determined to be "Finance." As the home-grown technology of Pakistan is not mature and compatible with global standards according to the data obtained from the subject experts, then to offer medical devices to the population would mean having to offer them from outside the country, which would make it considerably more costly for Pakistan's healthcare system and difficult to afford it for its long-term sustainability. The subject experts determined the subcriterion of "Policymaking" to be the next factor of importance in the study. In Pakistan, there is healthcare for all; however, it is not guaranteed and therefore the subject experts felt that the government would need to put its focus more on policymaking so that everyone is able to get a fairer share of healthcare products and services in the long term. Even though Pakistan has a long history of political instability, the subject experts gave the lowest importance to this subfactor. The reason for this was because finance and policymaking superseded political will in their professional opinion.

In the next set of study results, the main criteria of "Technical Factors" had the most significant importance as determined by the subject experts. The most important aspect of the chosen subfactors was "Risk." Some of the main risks identified throughout this study were failures in using medical devices and financial risks associated with getting adequate medical funding and continuity of good quality and reliable patient care. The subject experts also mentioned mitigating risks as a way to alleviate burdens placed on Pakistan's society and economy. The next subcriteria was "Device Durability" which focuses on advanced applications in a public environment. For example, most of the technology is cloud-based, and the question remains how it is possible for the patient to access and communicate with the technology everywhere, especially in Pakistan's urban and rural areas. The 3rd subfactor of "Infrastructure" was given this level of importance because the subject experts determined Pakistan to have a high rate of poverty, a lack of technological resources, and an unstable financial standing, and this was seen as challenges that the experts themselves had been seeing firsthand while they have been working "on the ground" as part of this reality.

Pakistan subject experts next gave "Device Lead Times" significance in this study because this was considered a lengthy and time-consuming process involving continuous new technological development and experimentation before being integrated into the commercial marketplace. Device lead times could either have a negative or positive impact on an economy depending on the right product at the right time and in the right place. The 5th of the subfactors of "Device Efficiency" was considered to be of next-level importance as medical devices need to be made efficient and effective for patient use and should not negatively impact a patient's quality of life. The experts felt that the efficiency of devices should meet patients' and healthcare professionals' expectations and be time and cost-saving without being considered marketing ploys. Lastly, the subfactor of "Device Maturity" was determined to be the lowest on the ranking

Table 8: C3—A pairwise comparison matrix with the subcriteria result.

	C31			C32			C33			C34			C35			C36			Weight
C31	1	1	1	0.4737	0.6553	0.9822	0.4983	0.7276	1.1140	0.4983	0.7598	1.1557	0.5390	0.8259	1.3993	0.3997	0.5878	0.8912	0.1250
C32	1.0181	1.5259	2.1110	1	1	1	0.5016	0.7147	1.0986	0.4855	0.6894	1.1185	0.5107	0.7654	1.2287	0.5238	0.7147	1.0520	0.1431
C33	0.8977	1.3743	2.0067	0.9103	1.3993	1.9935	1	1	1	0.5774	0.8409	1.3161	0.5238	0.7654	1.1980	0.5430	0.7518	1.1472	0.1628
C34	0.8653	1.3161	2.0067	0.8941	1.4505	2.0598	0.7598	1.1892	1.7321	1	1	1	0.4870	0.6993	1.1076	0.4405	0.5965	0.9007	0.1625
C35	0.7147	1.2108	1.8552	0.8138	1.3064	1.9580	0.8347	1.3064	1.9090	0.9336	1.4612	2.0818	1	1	1	0.4455	0.6230	0.9238	0.1801
C36	1.1221	1.7012	2.5021	0.9506	1.3993	1.9090	0.8717	1.3301	1.8416	1.1103	1.6763	2.2702	1.0825	1.6053	2.2444	1	1	1	0.2265

Table 9: C4—A pairwise comparison matrix with the subcriteria result.

	C41			C42			Weight
C41	1	1	1	0.5286	0.7137	0.9405	0.2878
C42	1.0632	1.4011	1.8916	1	1	1	0.7122

system by the subject experts due to the degree of difficulty involved in developing these devices locally in Pakistan, and the level of technological complexity associated with manufacturing and production is important and necessary for sustainable production.

The main criteria of "Economic Factors" was the least level of importance because Pakistan is considered as a low-income country, and the experts felt it was difficult to get costs covered through funding for devices that would be able to improve the rest of a patient's life. In this study, the experts surveyed economic factors that are more focused on immediate short-term solutions to this existing problem; therefore, they were giving more consideration to the consecutive costs for the patient devices. Because they wanted to see the immediate solution to this problem, they were focusing now on this factor rather than waiting for investment in future technology. Therefore, their precedence and preference are more based on the initial costs of the technological development of the devices rather than the consecutive costs.

The subject experts of Pakistan also identified and compared four main criteria factors in the following order of most importance to least importance: technical, economic, political/regulatory affairs and social/cultural values. Their comparison analysis of all the relevant criteria consists of both internal and external factors, which are covered mostly by SWOT and PEST analyses, but due to the novelty of this paper, both analyses have been done consecutively. The purpose of carrying out comparison analysis is that it allows us to make informed decisions while simplifying the alternatives and avoiding any bias in our studies. A research report that classifies typical response times and delivery success rates will be created that will benchmark the factors being compared.

The subject experts believe that Pakistan is considered a third-world country regarding technological factors which need to lay down the basic foundation of sustainable technology development as the first preference. The 2nd importance is the economic Factors as compared to technology versus the political/regulatory affairs because Pakistan is a low-income country, and it has to develop the local economy as solutions rather than having a dependency on external resources.The 3rd comparison which is most challenging and unique to third-world countries is the political/regulatory factors which focus on the democratic and regulatory institutions which is an ongoing process for each country. This is a constant refining process, and the subject experts believe that social/cultural factors should be considered as least important because of the globalization around us as well as the access to the information in the world. This comparison proves that subject experts believe that each country has to analyze and focus on its own set of parameters in the existing framework of its healthcare system of each country over time.

6.5. Application of VIKOR for Alternative Analysis. The VIKOR model now needs to test data of expert choices to find out the best funding source among alternatives then calculated. Table 10 shows the pairwise comparison matrix for alternatives.

6.6. Funding Alternative Composite Results. The VIKOR model is approached as the final part of the selection process, and an alternative rating decision matrix for each qualitative concerning criterion is presented in Table 11. The quantitative data used in this study are shown in Table 11, and it is important to note that the data in this table call forth only applies to low-income countries rather than the developed nation which has developed better socio-economic, regulatory institutions, technologies, and economics.

The next step is normalizing the decision matrix by equation (2). Now, we need to apply equations (3) and (4) to determine the ideal A (positive) or A^* (negative) ideal solution.

For B1: Technology acceptance (a larger B criteria value is preferred); $Pj^* = 0.5796$ and $Pj = 0.4118$

For B2: Job creation (a larger B criteria value is preferred); $Pj^* = 0.5979$ and $Pj = 0.4032$

For B3: Social change (a larger B criteria value is preferred); $Pj^* = 0.4183$ and $Pj = 0.5451$

For B4: Demography (a larger B criteria value is preferred); $Pj^* = 0.6028$ and $Pj = 0.4134$

For B5: Patient quality of life (a larger B criteria value is preferred); $Pj^* = 0.5641$ and $Pj = 0.4441$

For B6: Political stability (a larger B criteria value is preferred); $Pj^* = 0.5239$ and $Pj = 0.4531$

For B7: Policy making (a larger B criteria value is preferred); $Pj^* = 0.5372$ and $Pj = 0.4029$

For B8: Finance (a larger B criteria value is preferred); $Pj^* = 0.5419$ and $Pj = 0.3833$

For B9: Device maturity (NB: The lesser the number, the better); $Pj^* = 0.4409$ and $Pj = 0.6026$

For B10: Device efficiency (a larger B criteria value is preferred); $Pj^* = 0.5999$ and $Pj = 0.45871$

For B11: Infrastructure (a larger B criteria value is preferred); $Pj^* = 0.4339$ and $Pj = 0.6074$

For B12: Device lead time (a larger B criteria value is preferred); $Pj^* = 0.5454$ and $Pj = 0.4127$

For B13: Device durability (a larger B criteria value is preferred); $Pj^* = 0.4147$ and $Pj = 0.5836$

Table 10: Pairwise comparison LV matrix for each alternative concerning decision-makers.

Very low (VL) = 0.00, low (L) = 0.25, moderate (M) = 0.50, high (H) = 0.75, very high (VH) = 1.00

		Criteria															
Alternative	Expert	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
A1	Ex1	L	H	H	M	H	L	L	H	H	M	H	H	M	M	M	H
	Ex2	L	M	VH	H	VH	M	H	VH	H	VH	H	H	H	M	M	M
	Ex3	L	M	H	M	H	M	H	VH	H	M	H	H	M	M	M	M
	Ex4	L	M	H	M	H	M	H	VH	H	M	H	H	M	M	M	M
	Ex5	M	VH	M	M	VH	VH	M	H	M	H	VH	M	L	VL	VH	L
	Ex6	M	M	H	M	L	H	M	M	M	H	H	L	H	L	L	H
	Ex7	M	VH	VH	VH	VH	VH	VH	VH	H	H	H	L	M	VH	VH	H
	Ex8	H	VH	H	VH	H	VH	H	H	H	M	M	H	M	M	M	H
	Ex9	M	M	H	M	H	L	VL	M	M	L	M	L	M	H	H	H
	Ex10	VL	VL	L	H	VH	VL	VH	VL	H	VH	VL	H	VH	VL	VL	VL
	Ex11	M	H	H	M	L	M	H	M	H	VH	H	M	L	M	H	M
	Ex12	H	M	L	L	M	H	M	H	L	M	H	M	L	VL	M	L
	Ex13	H	L	L	M	H	L	M	M	VH	M	H	M	M	M	VH	M
	Ex14	H	H	M	M	H	M	M	H	L	M	M	M	M	L	L	H
	Ex15	M	M	H	L	H	M	M	VL	H	VH	M	H	H	L	M	M
	Ex16	M	H	H	L	H	M	M	VL	M	M	H	H	H	L	M	M
A2	Ex1	H	H	H	M	H	L	L	H	H	M	H	H	M	M	M	H
	Ex2	VH	M	VH	H	VH	M	H	VH	H	VH	H	H	H	M	VL	H
	Ex3	VH	M	H	M	H	M	H	VH	H	M	H	H	M	VL	H	H
	Ex4	H	M	H	M	H	M	H	VH	H	M	H	H	M	VL	H	H
	Ex5	VH	VH	H	L	H	H	VH	M	H	H	H	H	L	VL	H	M
	Ex6	H	M	H	M	L	H	M	M	M	H	H	L	H	M	M	H
	Ex7	H	VH	H	H	H	VH	VH	H	M	M	L	M	L	VH	H	M
	Ex8	M	H	H	H	H	H	H	M	M	L	L	M	L	L	L	M
	Ex9	VL	H	M	L	H	VL	M	L	L	M	L	M	L	M	M	M
	Ex10	VL	H	VH	L	VH	M	H	VL	VL	L	VL	VL	L	L	M	M
	Ex11	M	H	H	M	H	M	L	M	L	M	L	M	VL	M	L	M
	Ex12	H	M	M	L	M	H	M	H	L	M	H	M	L	VL	M	L
	Ex13	H	M	M	M	M	M	M	H	M	M	H	M	M	L	VH	M
	Ex14	M	M	L	M	L	M	L	M	L	VL	L	H	H	H	M	M
	Ex15	L	H	M	L	M	H	H	H	M	M	M	M	H	M	H	H
	Ex16	L	H	M	L	M	H	H	H	H	M	H	M	H	M	H	H
A3	Ex1	VH	M	M	M	H	M	M	H	M	H	H	H	VH	H	M	H
	Ex2	VH	M	VH	H	VH	M	H	VH	H	VH	H	H	H	VH	M	M
	Ex3	M	M	H	M	H	M	H	VH	H	M	H	H	VH	H	H	M
	Ex4	M	M	H	M	H	M	H	VH	H	M	H	H	L	M	H	M
	Ex5	H	H	VH	H	M	VH	H	H	H	M	H	H	M	L	M	L
	Ex6	H	M	M	M	M	H	L	M	M	H	M	L	H	L	H	H
	Ex7	VL	VL	L	M	M	H	H	M	L	L	L	H	H	H	L	L
	Ex8	H	M	M	M	M	H	M	M	M	VL	L	L	M	L	M	M
	Ex9	M	H	VH	M	M	M	M	M	M	L	M	M	L	H	M	H
	Ex10	M	M	H	VL	H	VL	H	M	L	M	VL	M	M	L	L	L
	Ex11	L	M	H	M	H	M	H	M	VL	H	M	M	H	M	H	M
	Ex12	L	M	M	L	M	H	M	H	L	M	L	M	L	VL	M	L
	Ex13	L	M	M	L	M	M	H	L	M	L	L	L	L	M	H	L
	Ex14	L	L	VL	L	L	L	L	L	VL	L	L	M	M	M	VL	L
	Ex15	H	M	M	L	H	H	H	H	H	H	H	M	H	L	VH	VH
	Ex16	H	M	M	L	H	H	H	H	M	M	M	M	H	L	VH	H

Table 10: Continued.

Very low (VL) = 0.00, low (L) = 0.25, moderate (M) = 0.50, high (H) = 0.75, very high (VH) = 1.00																	
		Criteria															
Alternative	Expert	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
A4	Ex1	L	M	M	M	H	M	L	H	M	H	H	H	VL	H	M	H
	Ex2	L	M	VH	H	VH	M	H	VH	H	VH	H	H	H	VL	M	L
	Ex3	L	M	H	M	H	M	H	VH	H	M	H	H	VL	M	H	L
	Ex4	L	M	H	M	H	M	H	VH	H	M	H	H	VL	M	H	L
	Ex5	M	H	H	L	H	H	M	L	M	H	M	M	H	L	L	VL
	Ex6	H	H	M	M	L	H	L	M	M	H	M	L	M	L	H	H
	Ex7	L	L	L	L	L	M	H	L	L	VL	L	VL	L	M	M	VL
	Ex8	L	L	H	L	M	M	M	L	L	L	M	M	L	VL	M	L
	Ex9	H	M	L	M	H	L	L	L	M	M	L	L	L	M	L	M
	Ex10	L	L	L	L	VH	H	L	H	H	H	M	M	H	M	M	M
	Ex11	M	M	H	M	H	M	H	M	M	M	M	M	H	M	H	M
	Ex12	M	L	M	L	M	H	M	H	L	M	L	M	L	VL	M	L
	Ex13	M	M	M	L	L	L	VL	VL	VL	L	VL	L	M	VH	VL	VL
	Ex14	M	L	L	L	VL	VL	L	VL	L	L	L	L	L	L	M	M
	Ex15	M	M	L	L	M	M	M	VL	M	M	M	L	H	H	L	M
	Ex16	M	M	L	L	M	M	M	VL	VH	M	M	L	H	H	L	M

A1-A4 represent Alternate Funding and B1-B16 represent Criteria.

Table 11: Alternative pairwise comparison matrix with respect to criteria.

	Criteria															
	C11	C12	C13	C14	C15	C21	C22	C23	C31	C32	C33	C34	C35	C36	C41	C42
A1	0.469	0.609	0.656	0.547	0.734	0.547	0.594	0.609	0.641	0.656	0.656	0.578	0.547	0.391	0.563	0.531
A2	0.594	0.672	0.672	0.453	0.656	0.578	0.625	0.641	0.500	0.500	0.531	0.547	0.453	0.375	0.563	0.594
A3	0.547	0.484	0.609	0.422	0.625	0.578	0.625	0.641	0.469	0.500	0.484	0.547	0.594	0.469	0.578	0.500
A4	0.422	0.453	0.516	0.375	0.578	0.500	0.469	0.453	0.500	0.516	0.469	0.438	0.422	0.438	0.469	0.359

Table 12: The S_{ij} matrix.

	S_{ij} matrix															
A1	0.0203	0.0022	0.6778	0.0126	0.0736	0.0213	0.0291	0.0299	0.0469	0.0172	0.0633	0.0121	0.0428	0.1031	0.1107	0.1544
A2	0.0026	0.0150	0.7234	0.0340	0.0398	0.0499	0.0450	0.0442	0.0138	0.0307	0.0276	0.0005	0.0124	0.1130	0.1107	0.2103
A3	0.0059	0.0230	0.5438	0.0410	0.0263	0.0499	0.0450	0.0442	0.0066	0.0307	0.0142	0.0005	0.0580	0.5514	0.1232	0.1269
A4	0.0289	0.0293	0.2786	0.0517	0.0060	0.0220	0.0350	0.0396	0.0138	0.0258	0.0100	0.0399	0.0023	0.0742	0.0322	0.0018

For B14: Risk (a smaller B criteria value is preferred); $Pj^* = 0.5585$ and $Pj = 0.4468$

For B15: Initial cost (a smaller B criteria value is preferred); $Pj^* = 0.43033$ and $Pj = 0.5302$

For B16: Consecutive cost (a smaller B criteria value is preferred); $Pj^* = 0.3569$ and $Pj = 0.5897$

To ensure alternative funding options are bias-free, unity and regret measure is performed. This offers a decision under uncertainty that research might discover on acknowledging results that another alternative might have been preferable.

For B1: Technology acceptance, Wj = 0.0308, $Pj^* = 0.5796$, and $Pj = 0.4118$.

$$
\begin{aligned}
S_{11a} &= 0.0308 \times \frac{0.5796 - 0.4690}{0.5796 - 0.4118} = 0.0203,\\
S_{11b} &= 0.0308 \times \frac{0.5796 - 0.5940}{0.5796 - 0.4118} = 0.0026,\\
S_{11c} &= 0.0308 \times \frac{0.5796 - 0.5470}{0.5796 - 0.4118} = 0.0059,\\
S_{11d} &= 0.0308 \times \frac{0.5796 - 0.4220}{0.5796 - 0.4118} = 0.0289.
\end{aligned}
\tag{17}
$$

For B2: Technology acceptance, Wj = 0.03946, $Pj^* = 0.5979$, and $Pj = 0.4032$.

$$S_{12a} = 0.03946 \times \frac{0.5979 - 0.6090}{0.5979 - 0.4032} = 0.0022,$$
$$S_{12b} = 0.03946 \times \frac{0.5979 - 0.6720}{0.5979 - 0.4032} = 0.0150,$$
$$S_{12c} = 0.03946 \times \frac{0.5979 - 0.4840}{0.5979 - 0.4032} = 0.0230,$$
$$S_{12\ d} = 0.03946 \times \frac{0.5979 - 0.4530}{0.5979 - 0.4032} = 0.0293. \quad (18)$$

For B3: Technology acceptance, Wj = 0.03616, $Pj^{*} = 0.4183$, and $Pj = 0.54511$.

$$S_{13a} = 0.3616 \times \frac{0.4183 - 0.6560}{0.4183 - 0.5451} = 0.6778,$$
$$S_{13b} = 0.3616 \times \frac{0.4183 - 0.6720}{0.4183 - 0.5451} = 0.7234,$$
$$S_{13c} = 0.3616 \times \frac{0.4183 - 0.6090}{0.4183 - 0.5451} = 0.5438,$$
$$S_{13d} = 0.3616 \times \frac{0.4183 - 0.5160}{0.4183 - 0.5451} = 0.2786. \quad (19)$$

For B4: Technology acceptance, Wj = 0.04301, $Pj^{*} = 0.6028$, and $Pj = 0.4134$.

$$S_{14a} = 0.04301 \times \frac{0.6028 - 0.5470}{0.6028 - 0.4134} = 0.0126,$$
$$S_{14b} = 0.04301 \times \frac{0.6028 - 0.4530}{0.6028 - 0.4134} = 0.034,$$
$$S_{14c} = 0.04301 \times \frac{0.6028 - 0.4220}{0.6028 - 0.4134} = 0.0410,$$
$$S_{14d} = 0.04301 \times \frac{0.6028 - 0.3750}{0.6028 - 0.4134} = 0.0517. \quad (20)$$

For B5: Technology acceptance, Wj = 0.05201, $Pj^{*} = 0.5641$, and $Pj = 0.4441$.

$$S_{15a} = 0.5201 \times \frac{0.5641 - 0.7340}{0.5641 - 0.4441} = 0.0736,$$
$$S_{15b} = 0.5201 \times \frac{0.5641 - 0.6560}{0.5641 - 0.4441} = 0.0398,$$
$$S_{15c} = 0.5201 \times \frac{0.5641 - 0.6250}{0.5641 - 0.4441} = 0.0263,$$
$$S_{15d} = 0.5201 \times \frac{0.5641 - 0.5780}{0.5641 - 0.4441} = 0.0060. \quad (21)$$

For B6: Technology acceptance, Wj = 0.06539, $Pj^{*} = 0.5239$, and $Pj = 0.4531$.

$$S_{21a} = 0.06539 \times \frac{0.5239 - 0.5470}{0.5239 - 0.4531} = 0.0213,$$
$$S_{21b} = 0.06539 \times \frac{0.5239 - 0.5780}{0.5239 - 0.4531} = 0.0499,$$
$$S_{21c} = 0.06539 \times \frac{0.5239 - 0.5780}{0.5239 - 0.4531} = 0.0499,$$
$$S_{21d} = 0.06539 \times \frac{0.5239 - 0.5000}{0.5239 - 0.4531} = 0.0220. \quad (22)$$

For B7: Technology acceptance, Wj = 0.0689, $Pj^{*} = 0.5372$, and $Pj = 0.4029$.

$$S_{22a} = 0.0689 \times \frac{0.5372 - 0.5940}{0.5372 - 0.4029} = 0.0291,$$
$$S_{22b} = 0.0689 \times \frac{0.5372 - 0.6250}{0.5372 - 0.4029} = 0.045,$$
$$S_{22c} = 0.0689 \times \frac{0.5372 - 0.6250}{0.5372 - 0.4029} = 0.0450,$$
$$S_{22d} = 0.0689 \times \frac{0.5372 - 0.4690}{0.5372 - 0.4029} = 0.0350. \quad (23)$$

For B8: Technology acceptance, Wj = 0.0707, $Pj^{*} = 0.5419$, and $Pj = 0.3833$.

$$S_{23a} = 0.0707 \times \frac{0.5419 - 0.6090}{0.5419 - 0.3833} = 0.0299,$$
$$S_{23b} = 0.0707 \times \frac{0.5419 - 0.6410}{0.5419 - 0.3833} = 0.0442,$$
$$S_{23c} = 0.0707 \times \frac{0.5419 - 0.6410}{0.5419 - 0.3833} = 0.0442,$$
$$S_{23d} = 0.0707 \times \frac{0.5419 - 0.4530}{0.5419 - 0.3833} = 0.0396. \quad (24)$$

For B9: Technology acceptance, Wj = 0.03798, $Pj^{*} = 0.4409$, and $Pj = 0.6026$.

$$S_{31a} = 0.0379 \times \frac{0.4409 - 0.6410}{0.4409 - 0.6026} = 0.0469,$$
$$S_{31b} = 0.0379 \times \frac{0.4409 - 0.5000}{0.4409 - 0.6026} = 0.013,$$
$$S_{31c} = 0.0379 \times \frac{0.4409 - 0.4690}{0.4409 - 0.6026} = 0.0066,$$
$$S_{31d} = 0.0379 \times \frac{0.4409 - 0.500}{0.4409 - 0.6026} = 0.0138. \quad (25)$$

For B10: Technology acceptance, Wj = 0.0434, $Pj^{*} = 0.5999$, and $Pj = 0.4587$.

$$S_{32a} = 0.0434 \times \frac{0.5999 - 0.6560}{0.5999 - 0.4587} = 0.0172,$$
$$S_{32b} = 0.0434 \times \frac{0.5999 - 0.5000}{0.5999 - 0.4587} = 0.030,$$
$$S_{32c} = 0.0434 \times \frac{0.5999 - 0.5000}{0.5999 - 0.4587} = 0.0307,$$
$$S_{32d} = 0.0434 \times \frac{0.5999 - 0.5160}{0.5999 - 0.4587} = 0.0258. \quad (26)$$

For B11: Technology acceptance, Wj = 0.04947, $Pj^* = 0.5999$, and $Pj = 0.4587$.

$$S_{33a} = 0.0494 \times \frac{0.4339 - 0.6560}{0.4339 - 0.6074} = 0.0633,$$
$$S_{33b} = 0.0494 \times \frac{0.4339 - 0.5310}{0.4339 - 0.6074} = 0.027,$$
$$S_{33c} = 0.0494 \times \frac{0.4339 - 0.4840}{0.4339 - 0.6074} = 0.0142,$$
$$S_{33d} = 0.0494 \times \frac{0.4339 - 0.4690}{0.4339 - 0.6074} = 0.0100. \quad (27)$$

For B12: Technology Acceptance, Wj = 0.0493, $Pj^* = 0.5454$ and $Pj = 0.412$

$$S_{34a} = 0.0493 \times \frac{0.5454 - 0.5780}{0.5454 - 0.4127} = 0.0121,$$
$$S_{34b} = 0.0493 \times \frac{0.5454 - 0.5470}{0.5454 - 0.4127} = 0.0005,$$
$$S_{34c} = 0.0493 \times \frac{0.5454 - 0.5470}{0.5454 - 0.4127} = 0.0005,$$
$$S_{34d} = 0.0493 \times \frac{0.5454 - 0.4380}{0.5454 - 0.4127} = 0.0399. \quad (28)$$

For B13: Technology acceptance, Wj = 0.0547, $Pj^* = 0.4147$, and $Pj = 0.5836$.

$$S_{35a} = 0.0547 \times \frac{0.4147 - 0.5470}{0.4147 - 0.5836} = 0.0428,$$
$$S_{35b} = 0.0547 \times \frac{0.4147 - 0.4530}{0.4147 - 0.5836} = 0.012,$$
$$S_{35c} = 0.0547 \times \frac{0.4147 - 0.940}{0.4147 - 0.5836} = 0.0580,$$
$$S_{35d} = 0.0547 \times \frac{0.4147 - 0.4220}{0.4147 - 0.5836} = 0.0023. \quad (29)$$

For B14: Technology Acceptance, Wj = 0.0688, $Pj^* = 0.5585$ and $Pj = 0.4468$

$$S_{36a} = 0.0688 \times \frac{0.5585 - 0.3910}{0.5585 - 0.4468} = 0.1031,$$
$$S_{36b} = 0.0688 \times \frac{0.5585 - 0.3750}{0.5585 - 0.4468} = 0.1130,$$
$$S_{36c} = 0.0688 \times \frac{0.5585 - 0.4690}{0.5585 - 0.4468} = 0.5514,$$
$$S_{36d} = 0.0688 \times \frac{0.5585 - 0.4380}{0.5585 - 0.4468} = 0.0742. \quad (30)$$

For B15: Technology acceptance, Wj = 0.0833, $Pj^* = 0.4303$, and $Pj = 0.5302$.

$$S_{41a} = 0.0833 \times \frac{0.4303 - 0.5630}{0.4303 - 0.5302} = 0.1107,$$
$$S_{41b} = 0.0833 \times \frac{0.4303 - 0.5630}{0.4303 - 0.5302} = 0.1107,$$
$$S_{41c} = 0.0833 \times \frac{0.4303 - 0.5780}{0.4303 - 0.5302} = 0.1232,$$
$$S_{41d} = 0.0833 \times \frac{0.4303 - 0.4690}{0.4303 - 0.5302} = 0.0322. \quad (31)$$

For B16: Technology acceptance, Wj = 0.2062, $Pj^* = 0.3569$, and $Pj = 0.5897$.

$$S_{42a} = 0.2062 \times \frac{0.3569 - 0.5310}{0.3569 - 0.5897} = 0.1544,$$
$$S_{42b} = 0.2062 \times \frac{0.3569 - 0.5940}{0.3569 - 0.5897} = 0.2103,$$
$$S_{42c} = 0.2062 \times \frac{0.3569 - 0.5000}{0.3569 - 0.5897} = 0.1269,$$
$$S_{42d} = 0.2062 \times \frac{0.3569 - 0.3590}{0.3569 - 0.5897} = 0.0018. \quad (32)$$

The same procedure is applied for the rest of the attributes concerning all alternatives which are computed and presented in the utility matrix S_{ij} in Table 12.

The unity measure and regret measure for all four alternatives are presented in Table 13.

Index value Qi for alternatives needs to be analyzed to identify and prove the validity of results for alternatives, as discussed in Section 3.2. The following calculations present the alternative solutions.

For Alternative A1,

$$\mathbf{Q_i} = (0.5)\left[\frac{0.5253 - 0.4520}{0.5253 - 0.4520}\right] + (1 - 0.5)\left[\frac{0.1512 - 0.0708}{0.2062 - 0.0708}\right] = 0.7970. \quad (33)$$

For Alternative A2,

Table 13: Unity and regret measures.

	Unity measure	Regret measure
A1	0.5253	0.1512
A2	0.5199	0.2062
A3	0.4520	0.1237
A4	0.4888	0.0708

Table 14: Results of Qi and ranking.

	A1: Self-pay	A2: Gov't pay	A3: Insurance pay	A4: Need-based
Qi	0.7970	0.9636	0.1956	0.2510
Ranking	3rd	4th	1st	2nd

Table 15: Sensitivity analysis.

ν	A1	A2	A3	A4	Ranking
(0.1)	0.6347	0.9927	0.3520	0.0502	A4 < A3 < A1 < A2
(0.2)	0.6753	0.9854	0.3129	0.1004	A4 < A3 < A1 < A2
(0.3)	0.7159	0.9781	0.2738	0.1506	A4 < A3 < A1 < A2
(0.4)	0.7565	0.9709	0.2347	0.2008	A4 < A3 < A1 < A2
(0.5) current	0.7970	0.9636	0.1956	0.2510	A3 < A4 < A1 < A2
(0.6)	0.8376	0.9563	0.1565	0.3012	A3 < A4 < A1 < A2
(0.7)	0.8782	0.9490	0.1173	0.3514	A3 < A < A1 < A2
(0.8)	0.9188	0.9417	0.0782	0.4016	A3 < A4 < A1 < A2
(0.9)	0.9594	0.9344	0.0391	0.4518	A3 < A4 < A1 < A2

Table 16: Appendix A: Expert's demographic information.

Subject Expert's demographic information Justification	Participants	Qualification	Department
Stakeholder in healthcare, policy, regulatory affairs, finance, and decision-making	Rehabilitation professor (physical and medical rehabilitation)	MBBS, FCPS	IPMR SINDH health Care Facility
Government officials responsible for policy, planning, finance, and decision-making.	Secretary (additional) planning	MBA, MPH	Sindh Secretariat
Government officials for economics analysis and financing	Health economist	MSc. Economics	AGPR Sindh
Government office revenue collection	Finance planner-tax officer	MBA	Federal Board of Revenue
Healthcare provider	Clinician-physiotherapist	DPT	Dr. RUTH K. M. KHI
Direct healthcare provider	Clinician prosthetist orthotist	Postgraduate studies	IPMR Sindh

$$\mathbf{Q_i} = (0.5)\left[\frac{0.5199 - 0.4520}{0.5253 - 0.4520}\right] + (1 - 0.5)\left[\frac{0.2062 - 0.0708}{0.2062 - 0.0708}\right] = 0.9636. \tag{34}$$

For Alternative A3,

$$\mathbf{Q_i} = (0.5)\left[\frac{0.4520 - 0.4520}{0.5253 - 0.4520}\right] + (1 - 0.5)\left[\frac{0.1237 - 0.0708}{0.2062 - 0.0708}\right] = 0.1956. \tag{35}$$

For Alternative A4,

$$\mathbf{Q_i} = (0.5)\left[\frac{0.4888 - 0.4520}{0.5253 - 0.4520}\right] + (1 - 0.5)\left[\frac{0.0708 - 0.0708}{0.2062 - 0.0708}\right] = 0.2510. \tag{36}$$

The index value considers the best solution and high rank when the index value has the smallest value for proposed alternative funding. Study results rank the funding for a medical device with the minimum value for A3 related to "private insurance" paid with a low index value Qi of 0.1956 as 1st choice and 2nd choice is "need-based" as A4. "Self-pay" A1 has the 3rd choice ranking with "government pay" A2 option as the least valued choice as shown in Table 14.

7. Sensitivity Assessment

Sensitivity assessment analyzes the value effect of parameter creation on the findings resulting from the decision-making process, which is otherwise known as a sensitivity analysis. It analyzed the important findings with regard to changes in values from 0.1 to 0.9. When "v" value is 0.5, then A3 and A4 are the best alternatives compared to the reduced "v" value of 0.5 to 0.1, while A3 and A4 have the same results of best alternatives when "v" value changes from 0.5 to 0.9. Decision-makers consider selecting the best option among available alternatives by limiting any bias in the values. All four alternatives are presented in Table 15.

This paper analyzed four main criteria and 16 subcriteria using an integrated FAVIKOR-based model designed to determine the best funding source in Sindh, Pakistan. During case analysis, private insurance funding was shown to have the highest weightage value at 0.30386 for the most significant selective criteria, followed by need based as the 2$^{\text{nd}}$ highest with a weightage value of 0.28958. Other subfactors, such as political instability, societal change, device, and cost received the lowest scores which could be owing to a lack of awareness of each country's particular financial culture. It shows that the funding factors for choosing a private insurance operating option have the highest preference, with the experts emphasizing the expense of medical equipment technology being imported from other countries as well as the economic elements of a lack of a robust healthcare policy as the main concerns. Furthermore, from the standpoint of clinicians, the demography vs. technology subcriterion was found to be of critical significance.

Experts felt certain that such subcriteria would reduce the negative financial and technological effects. Due to the low income per capita, experts believed that financial problems were more important than any other factor in embracing and utilizing private insurance funding. In terms of social and cultural points of view, demographic subcriteria were more critical than any other parameters such as technology acceptance, job creation, social change, and patient quality of life because it covers all aspects of success in society. In terms of technology aspect criteria, the subcriteria of device efficiency has a better ranking than other technology factors such as device, infrastructure, or risk because technology always changes with research and design parameters. In terms of political and regulatory affairs, political instability is deemed to be highly important than policy because since Pakistan's independence in 1947, dictatorship has continuously disrupted democracy which can make healthcare policy difficult to be consistent. From the economic point of view for funding advanced P&O medical device subcriteria, the initial cost is assumed to be more influential than the consecutive cost because it is considered a new beginning or chance at regaining quality of life for patients. The study also finds that private insurance should pay for advanced P&O medical devices because private insurance secured the lowest Qi score (0.1956); therefore, private insurance funding should be considered the best funding source in Pakistan, followed by government need-based (0.2510).

8. Conclusion

This research study designed an integrated FAHP/VIKOR model for the purpose of selecting best financial source alternatives for advanced P&O medical devices in low-income countries using prioritization of funding alternatives based on main criteria and subcriteria. Limitations included sample number of study participants, amount of data collected, number of models used, and time constraints. The result of this study showed that "private insurance" was the best funding solution, and from then onward, from all those from best to least were "need-based," "self-pay," and finally "government-based," having the least weightage value. The fuzzy AHP model's main criteria were technical, economics, political/regulatory affairs and social/cultural values. Technological acceptance, political instability, devices efficiency, and consecutive cost were also of least weightage value on the ranking scale. The results of the sensitivity analysis showed the value effect of parameter creation on the findings resulting from the decision-making process and showed changes in values that ranged from 0.1 to 0.9. Decision-makers chose the best option among available alternatives with the limitation of any bias in the value results.

Findings from this first-time study show that health economic analyses are valuable tools to help us better understand funding challenges in low-income countries and their need for stable cost coverage to benefit the patient in an advanced P&O medical device system of the future. Having a single payment or diversified financial payment mix solution for funding advanced P&O medical devices may be a reasonable solution. Research findings from the weightage value ranking system of our newly designed FAHP/VIKOR model support the fact that private insurance needs to step up and do more to help these disabled communities and should create new policies that include funding solutions for advanced P&O medical devices. In order to improve future funding in countries such as Pakistan that have health economic challenges, much work is needed at varying levels that include policy, economics, finance, strategic planning, social benefits, sustainable long-term funding, technology, and clinical profession areas in order to create better awareness about fund sourcing by identifying what is of most importance in health economic systems so that efforts may be made by private insurance for consideration in funding of advanced P&O medical devices.

The Pakistan case study completed as part of this research identified the importance of investment in technological and rankings of financial sources. From our integrated model, it is recommended that advanced P&O medical devices need to [28] have guaranteed funding provided by private insurance and one way to do this would be in the form of a comprehensive [56] healthcare package. From a long-term financial point of view, private insurance funding is more secure than other alternative [61] solutions identified in this study, and therefore, it is recommended that private insurance should include a policy [65] that would allocate secure funding for advanced P&O medical devices as inclusion into Pakistan's health economic framework. Financial sourcing for advanced P&O medical devices can help Sindh Pakistan's amputees become more independent in their life, able to get jobs, and help them progress within their society rather than become a burden on it. It can also help local and international investors decide on long-term and short-term financial priorities to establish manufacturing and services in this study area. This research is a milestone in improving the quality of life for disabled people in low-income countries by bringing awareness to the need for increased healthcare access in Pakistan. Lastly, this study and methodology should be explored in other low-income countries and using new parameters, criteria, and subcriteria which can be developed and customized using similar AHP/VIKOR models.

Data Availability

All the data are included in the article.

Conflicts of Interest

The authors declare that they have no known conflicts of financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors' Contributions

The authors contributed equally to this work. Irfan Ahmed contributed conceptualization, writing original draft, visualization, and investigation. Bo Feng contributed conceptualization, writing review, and editing. Daud Abdul contributed conceptualization, investigation, writing review and editing. Junwen Feng contributed conceptualization, supervision, writing review, and editing.

Acknowledgments

This research is supported by Postgraduate Research and Practice Innovation Program of Jiangsu Province (No. KYCX22_0561).

References

[1] K. Diaconu, Y. F. Chen, C. Cummins, G. Jimenez Moyao, S. Manaseki-Holland, and R. Lilford, "Methods for medical device and equipment procurement and prioritization within low- and middle-income countries: findings of a systematic literature review," *Globalization and Health*, vol. 13, 2017.

[2] M. S. Bobka, "The 21 CFR (Code of Federal Regulations) online database: Food and Drug Administration regulations full-text," *Medical Reference Services Quarterly*, vol. 12, no. 1, p. 7, 1993, https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm.

[3] A Comprehensive Approach For Medical Device Development, *Incorporating Regulations, Critical Factors And Design For X In Modeling A Conceptual Framework*, 2012.

[4] Washington State Health Care Authority, *Prosthetic and Orthotic (P&O) Devices Billing Guide*, https://www.hca.wa.gov/assets/billers-and-providers/prosthetic-and-orthotic-bg-20201001.pdf, 2020.

[5] M. Behzadian, S. Khanmohammadi Otaghsara, M. Yazdani, and J. Ignatius, "A state-of the-art survey of TOPSIS applications," *Expert Systems with Applications*, vol. 39, no. 17, Article ID 13051, 2012.

[6] D. Abdul, J. Wenqi, and A. Tanveer, "Prioritization of renewable energy source for electricity generation through AHP-VIKOR integrated methodology," *Renewable Energy*, vol. 184, pp. 1018–1032, 2022.

[7] D. Abdul and J. Wenqi, "Evaluating appropriate communication technology for smart grid by using a comprehensive decision-making approach fuzzy TOPSIS," *Soft Computing*, vol. 26, no. 17, pp. 8521–8536, 2022.

[8] K. Shahzad, B. Lu, and D. Abdul, "Entrepreneur barrier analysis on renewable energy promotion in the context of Pakistan using Pythagorean fuzzy AHP method," *Environmental Science & Pollution Research*, vol. 29, no. 36, pp. 54756–54768, 2022.

[9] P. A. Alvarez, A. Ishizaka, and L. Martínez, "Multiple-criteria decision-making sorting methods: a survey," *Expert Systems with Applications*, vol. 183, Article ID 115368, 2021.

[10] Z. Yue, "A method for group decision-making based on determining weights of decision makers using TOPSIS," *Applied Mathematical Modelling*, vol. 35, no. 4, pp. 1926–1936, 2011.

[11] D. Kacprzak, "Fuzzy topsis method for group decision making," *Multiple Criteria Decision Making*, vol. 13, pp. 116–132, 2018.

[12] S. Evers, E. Goossens, A. Andr´ et al., "Criteria List for Assessment of Methodological Quality of Economic Evaluations: Consensus on Health Economic Criteria," *International Journal of Technology Assessment in Health Care*, vol. 21, 2005.

[13] L. Clarke, M. P. Dillon, and A. Shiell, "A systematic review of health economic evaluation in orthotics and prosthetics: Part 2-orthotics," *Prosthetics and Orthotics International*, vol. 45, no. 3, pp. 221–234, 2021.

[14] S. Shahabi, S. Pardhan, A. Ahmadi Teymourlouy et al., "Prioritizing solutions to incorporate Prosthetics and Orthotics services into Iranian health benefits package: using an analytic hierarchy process," *PLoS One*, vol. 16, no. 6, Article ID e0253001, 2021.

[15] C. S. Harkins, A. McGarry, and A. Buis, "Provision of prosthetic and orthotic services in low-income countries: a review of the literature," *Prosthetics and Orthotics International*, vol. 37, no. 5, pp. 353–361, 2013.

[16] O. S. Albahri, A. A. Zaidan, B. B. Zaidan et al., "New mHealth hospital selection framework supporting decentralised telemedicine architecture for outpatient cardiovascular disease-based integrated techniques: haversine-GPS and AHP-VIKOR," *Journal of Ambient Intelligence and Humanized Computing*, vol. 13, no. 1, pp. 219–239, 2022.

[17] O. S. Albahri, A. A. Zaidan, M. M. Salih et al., "Multidimensional benchmarking of the active queue management methods of network congestion control based on extension of fuzzy decision by opinion score method," *International Journal of Intelligent Systems*, vol. 36, no. 2, pp. 796–831, 2021.

[18] T. J. Mohammed, A. S. Albahri, A. A. Zaidan et al., "Convalescent-plasma-transfusion intelligent framework for rescuing COVID-19 patients across centralised/decentralised telemedicine hospitals based on AHP-group TOPSIS and matching component," *Applied Intelligence*, vol. 51, no. 5, pp. 2956–2987, 2021.

[19] N. K. Ibrahim, N. S. Jalood, M. J. Baqer et al., "Multi-criteria evaluation and benchmarking for young learners' English language mobile applications in terms of LSRW skills," *IEEE Access*, vol. 7, Article ID 146620, 2019.

[20] H. Işik and S. Arslan, "An artificial neural network classification approach for use the ultrasound in physiotherapy," *Journal of Medical Systems*, vol. 35, no. 6, pp. 1333–1341, 2011.
[21] I. Ozsahin, B. Uzun, and D. U. Ozsahin, "Selection of photodetectors in nuclear medical imaging using MCDM methods," *Journal of Instrumentation*, vol. 17, no. 06, Article ID C06003, 2022.
[22] C. Ayca and K. Hasan, "An application of fuzzy analytic hierarchy process (FAHP) for evaluating students project," *Educational Research and Reviews*, vol. 12, no. 3, pp. 120–132, 2017.
[23] G. A. P. G. van Mastrigt, M. Hiligsmann, J. J. C. Arts et al., "How to prepare a systematic review of economic evaluations for informing evidence-based healthcare decisions: a five-step approach (part 1/3)," *Expert Review of Pharmacoeconomics & Outcomes Research*, vol. 16, no. 6, pp. 689–704, 2016.
[24] A. F. Ozok, "Fuzzy modelling and efficiency in health care systems," *Work*, vol. 41, pp. 1797–1800, 2012.
[25] I. Chamodrakas, D. Batis, and D. Martakos, "Supplier selection in electronic marketplaces using satisficing and fuzzy AHP," *Expert Systems with Applications*, vol. 37, no. 1, pp. 490–498, 2010.
[26] M. S. Dwi Putra, S. Andryana, Fauziah, and A. Gunaryati, "Fuzzy analytical hierarchy process method to determine the quality of gemstones," *Advances in Fuzzy Systems*, vol. 2018, Article ID 9094380, 6 pages, 2018.
[27] A. S. Albahri, J. R. Al-Obaidi, A. A. Zaidan et al., "Multi-biological laboratory examination framework for the prioritization of patients with COVID-19 based on integrated AHP and group VIKOR methods," *International Journal of Information Technology and Decision Making*, vol. 19, 2020.
[28] N. Badie, A. Razak, C. Hussin et al., "Cloud Computing Data Center Adoption Factors Validity by Fuzzy AHP," *International Journal of Computational Intelligence Systems*, vol. 8, 2015.
[29] E. Yadegaridehkordi, M. H. Nizam Bin Md Nasir, N. Fazmidar Binti Mohd Noor, L. Shuib, and N. Badie, "Predicting the adoption of cloud-based technology using fuzzy analytic hierarchy process and structural equation modelling approaches," *Applied Soft Computing*, vol. 66, pp. 77–89, 2018.
[30] S. Opricovic and G. H. Tzeng, "Compromise solution by MCDM methods: a comparative analysis of VIKOR and TOPSIS," *European Journal of Operational Research*, vol. 156, no. 2, pp. 445–455, 2004.
[31] B. T. Shaikh and J. Hatcher, "Health seeking behaviour and health service utilization in Pakistan: challenging the policy makers," *Journal of Public Health*, vol. 27, no. 1, pp. 49–54, 2005.
[32] T. Collins, "Health policy analysis: a simple tool for policy makers," *Public Health*, vol. 119, no. 3, pp. 192–196, 2005.
[33] M. Al-Mana, M. Harris Shoaib, F. Ahmed Farooqi, and H. Ali, "Out of pocket (OOP) cost of treating hypertension in Karachi," *Pak J Pharm Sci*, vol. 31, 2018.
[34] Y. Teerawattananon, P. Kingkaew, T. Koopitakkajorn et al., "Development of a health screening package under the universal health coverage: the role of health technology assessment," *Health Economics*, vol. 25, pp. 162–178, 2016.
[35] D. Cummings, "Prosthetics in the developing world: a review of the literature," *Prosthetics and Orthotics International*, vol. 20, no. 1, pp. 51–60, 1996.
[36] A. Kroeger, "Anthropological and socio-medical health care research in developing countries," *Social Science & Medicine*, vol. 17, no. 3, pp. 147–161, 1983.
[37] A. Vossberg, "The Choice of Prosthetic and Orthotic Technique for Less Developed Countries: Analysis and Perspectives in Colombia," *Prosthet Orthot Int*, vol. 12, 1988.
[38] K. Kuca, P. Maresova, M. Penhaker, and A. Selamat, "The potential of medical device industry in technological and economical context," *Therapeutics and Clinical Risk Management*, vol. 11, pp. 1505–1514, 2015.
[39] L. Magnusson, R. Ghosh, K. R. Jensen et al., "Quality of life of prosthetic and orthotic users in South India: a cross-sectional study," *Health and Quality of Life Outcomes*, vol. 17, no. 1, p. 50, 2019.
[40] L. Magnusson, *Prosthetic and Orthotic Services in Developing Countries*, Jönköping University, Jönköping, Sweden, 2014.
[41] I. De-Rosende Celeiro, L. Simón Sanjuán, and S. Santos-del-Riego, "Activities of daily living in people with lower limb amputation: outcomes of an intervention to reduce dependence in pre-prosthetic phase," *Disability & Rehabilitation*, vol. 39, no. 18, pp. 1799–1806, 2017.
[42] J. S. Rekant, L. E. Fisher, M. L. Boninger, R. A. Gaunt, and J. L. Collinger, "Amputee, clinician, and regulator perspectives on current and prospective upper extremity prosthetic technologies," *medRxiv*, vol. 2020, 2020.
[43] T. Rothmund, J. C. Becker, and J. T. Jost, "The psychology of social justice in political thought and action," *Handbook of Social Justice Theory and Research*, pp. 275–291, 2016.
[44] A. Çela and E. Hysa, "Impact of political instability on economic growth in CEE countries," *Economy of Region*, vol. 17, no. 2, pp. 582–592, 2021.
[45] A. R. Nawaz, U. Anwar, and F. Aquil, "An economic impact of political instability: an evidence from Pakistan," *J. Econ. Impact.*vol. 3, no. 1, pp. 47–54, 2021.
[46] M. H. Fisher, "Pakistan: A Modern History. By Ian Talbot," *Journal of Asian Studies*, vol. 59, pp. 787-788, 2000.
[47] G. A. Heeger, "Politics in the post-military state: Some reflections on the Pakistani experience," *World Politics*, vol. 29, no. 2, pp. 242–262, 1977.
[48] A. Vatter and C. Rüefli, "Do political factors matter for health care expenditure? A comparative study of Swiss Cantons," *Journal of Public Policy*, vol. 23, no. 3, pp. 301–323, 2003.
[49] S. M. Mousavi, M. Jafari, and A. Vosoogh-Moghadam, "Integrated framework to improve health policy implementation in the way of Iran 2025 vision: bridging policy to practice gap in developing countries," *Journal of Education and Health Promotion*, vol. 9, p. 73, 2020.
[50] K. Anuar Abdullah and M. Hanafiah Juni, "POLICY ARENA OF HEALTH POLICY-MAKING PROCESS IN DEVELOPING COUNTRIES," *International Journal of Public Health and Clinical Sciences*, vol. 5, 2018.
[51] H. V. Fineberg, "A successful and sustainable health system — how to get there from here," *New England Journal of Medicine*, vol. 366, no. 11, pp. 1020–1027, 2012.
[52] V. Raghupathi and W. Raghupathi, "Healthcare expenditure and economic performance: insights from the United States data," *Frontiers in Public Health*, vol. 8, p. 156, 2020.
[53] R. Nuscheler, K. Cuff, J. Hurley B, S. Mestelman, and A. Muller E, "Public and Private Health Care Financing with Alternate Public Rationing Rules," *Health Econ*, vol. 21, 2007.

[54] K. Dooley, A. Subra, and J. Anderson, "Maturity and its impact on new product development project performance," *Research in Engineering Design*, vol. 13, no. 1, pp. 23–29, 2001.

[55] F. Hu, L. Qiu, and H. Zhou, "Medical device product innovation choices in asia: an empirical analysis based on product space," *Frontiers in Public Health*, vol. 10, Article ID 871575, 2022.

[56] M. A. Hossain, M. Ahmad, M. R. Islam, and Y. David, "Evaluation of performance outcomes of medical equipment technology management and patient safety: skilled clinical engineer's approach," *Global Clinical Engineering Journal*, vol. 1, no. 2, pp. 4–16, 2019.

[57] M. Sezdi, "Performance analysis for medical devices," *Biomedical Engineering Research*, pp. 139–146, 2013.

[58] B. Compton, D. M. Barash, J. Farrington et al., "Access to medical devices in low-income countries: addressing sustainability challenges in medical device donations," *NAM Perspectives*, vol. 8, no. 7, 2018.

[59] WIPO, D. Tang and W. Intellectual Property Organization Wipo, *WIPO Technology Trends 2021: Assistive Technology*.

[60] R. Ravichandran, R. P. Balakrishnan, J. S. D. Batcha, A. L. Ravi, and N. C. Sam, "Medical device: a complete overview," *Int. J. Clin. Trials.*vol. 7, no. 4, p. 285, 2020.

[61] V. Hegde, "Reliability in the medical device industry," *In: K. B. Misra, (eds) Handbook of Performability Engineering*, Springer, London, UK, 2008.

[62] S. Nayak and R. K. Das, "Application of artificial intelligence (AI) in prosthetic and orthotic rehabilitation," *Service Robot*, 2020.

[63] C. Sauter, M. Heinloth, A. Tobola, N. Pensky, and C. Weigand, "Risk management for medical devices in research projects," *Current Directions in Biomedical Engineering*, vol. 1, pp. 543–546, 2015.

[64] CEIC, *About CEIC - Financial Data & Economic Indicators*, CEIC, London, UK, 2019, https://www.ceicdata.com.

[65] Provincial Assembly of Sindh, Sindh Act No. XLVIII OF 2018, *Sindh Empowerment of "Persons with Disabilities" Act 2018*, https://itacec.org/document/2018/Sindh-Empowerment-of-PWD-Act-XLVIII-of-2018-june-11-2018.pdf.

[66] CEIC, The World Bank, *Pakistan household income per capita 2005 – 2022*, CEIC Data, London, UK, 2019, https://www.ceicdata.com/en/indicator/pakistan/annual-household-income-per-capita.