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ORIGINAL PAPER

AN ANALYTICAL HIERARCHY PROCESS-BASED DECISION MAKING FOR SUSTAINABLE MEDICAL DEVICES DEVELOPMENT

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ABSTRACT. Background: The medical device industry needs to be sustainable and should consider the safest, trusted quality and accessibility for use when they are required for patient diagnostic procedures. This study is conducted to identify the factors influencing sustainable development of medical devices.
Methods: The analytical hierarchy process (AHP) is being adopted to prioritize the influencing factors. Based on the classified criteria, the alternative factors are evaluated and compared with each other using AHP to make an optimal selection.
Results: The findings show that there are six main factors and seventeen sub-factors in this study that can support the development of sustainable medical devices. This study provides useful information for the medical device supplier to improve their current and future product design toward sustainable medical device development.
Conclusions: This study adds to the understanding of sustainable medical device development and its consequences on the intention to use from the consumer's perspective.

Keywords: medical device, new product development, sustainability, product management, analytical hierarchy process (AHP)

INTRODUCTION

The healthcare industry has evolved and has integrated various sectors that offer products and services to treat patient diseases effectively and in real time. The healthcare industry is considered one of the major sectors that incur a huge amount of expenditure. This is because this sector offers a modern treatment approach with the adoption of technological advancement. To achieve that, the process involved several areas such as medical device supplies, pharmaceuticals, and related medical technology. Currently, the healthcare industry is also constantly transforming into a sophisticated system through the use of modernised innovation technology [Bulatnikov & Constantin 2021]. Advances in medical technology are offering companies a great opportunity to introduce new innovative products to the market. At the same time, the quality of products and services has become the primary concern for medical device companies, which have been operating in an increasingly competitive environment.

Each medical device company has a different standard in defining product quality because many development processes are receiving a lot of attention. While it is a fact that the medical device industry considers three main features, namely safety, usability, and efficacy of a product. However, sustainable product design and development play a major role in these characteristics. Similarly, the requirement to become a sustainable manufacturing organization is another burdensome challenge faced by most of the industry players. Environmentally conscious design, green design, or sustainable design have become a major topic [Duangpun et al. 2019]. Sustainable product design is now a key component of significant

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change in business operations. It is in line with the Sustainable Development Goals (SDGs), no SDG 9 and SDG 12 on industrial innovation and infrastructure, and responsible consumption and production.

Medical devices play the most essential role in diagnosing, preventing, monitoring, alleviating, and treating diseases. It helps improve the quality of life by providing innovative healthcare solutions, including for people with disabilities. However, the medical device industry has a hard time identifying the influencing factors that contribute to sustainable product development. The particular problem with the industry is that the majority of suppliers in the healthcare industry business leaders struggle to minimize the expenses associated with product design and development [Erdogan & Tosun 2021]. However, the consensus of experts may not recognize the problems and obstacles associated with this situation due to a lack of knowledge of the industry environment. Therefore, the objective of this study is to investigate the factors for the sustainable development of medical devices.

This study contributes to both academics and practitioners. From the academic perspective, this study adds to the understanding of sustainable medical device development and its consequences on the intention to use from the consumer's perspective. Like this study, this study added value by offering insight to medical device suppliers to enhance their current product development. Customer experience is in fact important to encourage loyalty and future use of medical device products. This would be one of the competitive advantages among medical device suppliers.

This paper is divided into five sections. In Section 2, a literature review is presented followed by section 3 where a discussion on the methodology used for data collection and analysis is revealed. The results of the study are shown and discussed in Section 4 while section 5 deliberated on the conclusion and possible areas for further research.

LITERATURE REVIEW

The new tendency in contemporary business

Currently, various sectors are promoting sustainable product development towards strengthening their brand in the market and positioning themself in a competitive market. However, in the medical device industry, the application of product design and development in relation to the sustainability approach is still in the infancy stage. Furthermore, cost pressures, lack of knowledge, and lack of resources to invest in the process of business improvement are among the barriers that hinder industry players to opt for sustainable product development [Bitkina et al. 2020]. Furthermore, Guzzo et al. [2020] highlighted that healthcare providers are finding an innovative solution for a fruitful opportunity to optimize sustainable medical device supply chains, particularly green purchasing-related activities. In comparison, the adoption of sustainable practices in the manufacturing industry enables businesses to maintain a robust position that leads to long-term business success. It also complies with a monitoring requirement and gives new opportunities to run the business [Bag et al. 2020].

Product development

Product development involves the actions of creating a new product and bringing it to the marketplace or improving current products by adding more features to meet consumer demand and needs. The development of a medical device that provides a good quality product in both capital-intensive and technology-intensive environments requires the best set of human skills from different multidisciplinary backgrounds. It includes engineers and users, such as medical doctors, who are typically not actively involved in sustainable product development [Bitkina et al. 2020]. Therefore, the most important point in successful medical device product development is a well-defined overall design [Abdel-Basset et al. 2019]. However, traditional product design focuses on product functionalities, volume, and lower costs in meeting customer requirements. On the other hand, sustainable product design plans, company business model, company size, medical device products manufactured, and a systematic approach help manage products across the lifecycle.

Sustainable and eco-product design

To produce a sustainable product, specific requirements must be met from various stakeholders' perspectives. From the consumer's point of view, price and quality will be the primary concern. Quality is the measurement of product excellence or the state of being free of weakness [Yi & Liu 2020]. From the producer's perspective, aspects that are taken into account are materials, manufacturing process, product usage, and end-of-life product care [Ngatilah et al. 2018]. Well-designed and high-quality medical products are essential in providing safe conditions and effective clinical treatment to patients. To respond to all these matters, the design of the medical device and its functionality must meet the intended users when designing medical devices. Thus, stakeholders with different positions and backgrounds should be involved from the design stage to the product application.

Factors affecting sustainable product design and development

To produce a sustainable product, the product itself must meet the user's requirements. However, there are other factors that users are looking at before a purchase decision. Table 1 shows some of the most prominent influencing factors related to this study based on previous research.

Table 1. List of the influencing factors

Main factor	*Sub-factors*	*Source*
Price	Affordable concerning quality, High concerning quality	[Weber 2020; Zhang et al. 2018]
Quality	Operating quality, Speed, Durability, User-friendliness, Energy saving	[Behera & Dash 2018; Zhang et al. 2018; Weber 2020]
Service	On-time service, Easy maintenance	[Majchrzak-Lepczyk & Bober 2016; Zhang et al. 2018]
Reliability	No toxic material released, Safety and security	[Chanques et al. 2020; Chen & Liu 2016]
Appearance	Size, Weight, Portable, Stationary	[Gannam et al. 2018; Kaspar & Vielhaber 2017]
End-of-life	Recyclability, Disposability	[Guzzo et al. 2020; De Aguiar et al. 2017]

The top of the list is the price of the product itself. It refers to the affordable price with respect to the quality of the product. The customer is always looking for a reasonable price that suits the quality of the product over other aspects. Customers may choose to buy a product that is durable for long-term use due to financial constraints [Weber 2020]. However, if they could find a good quality product at a less expensive price, that would be more attractive. On the other hand, high-quality products usually come at a high price. However, for healthcare products, quality is the priority because it is related to patient life [Zhang et al. 2018].

The second important factor is the operating quality. It refers to how well the product can operate towards improving a patient's life. This can be found when the product is tested and used at the point of consumption. It also includes speed, which is considered the main concern of product performance or the ability of the product capability [Zhang et al. 2018]. Similarly, product durability is also important, in terms of the resilience that the product possesses in the environment in which it is used. Customers are also looking for a product that is user-friendly [Weber 2020]. Quality is also concerned with the energy savings of a product that consumes less electricity [Behera & Dash 2018].

The next factor is the service offered by the product. It includes on-time service, which is the service delivery of the product when it is ordered or needed. This requires clear communication between the respected providers and users. Therefore, an agile response is needed to ensure smooth processes from point of origin to point of consumption [Zhang et al. 2018]. Comparable products with easy maintenance will be highly demanded. Furthermore, assembling the components of the product affects the start-up times and the quality of the product's performance. Therefore, it is important to ensure that the service offered during and after sale can sustain the competitive advantage [Majchrzak-Lepczyk & Bober 2016].

Like in the case above, reliability is another important factor of consideration. No toxic material released is a sub-factor of consideration. This is because it can damage environmental health when the product is disposed of either in a landfill or in an incineration site. Therefore, the material selected for the product must be checked in detail [Chen & Liu 2016]. Similarly, safety and security are also important in that no adverse event should happen when the product is in use. In particular, some products can be accessed by wireless connection, hence, the system control must be highly secure. It is also important to ensure that the safety and security of the product are maintained [Chanques et al. 2020].

Next, the other important factor is appearance. Appearance is associated with the size or dimensions of the whole product [Gannam et al. 2018]. Different product sizes may be needed for different purposes, depending on the condition of use. Subsequently, the appearance also relates to the portability of the product. It is the ability of the product to be brought in or moved from one place to another. Additionally, stationary is also important in the aspect of product appearance. It refers to a product that cannot be moved from one place to another. For example, CT scanners and other infusion devices are designed to remain in the same position due to the system's complexity, size, and weight [Kaspar & Vielhaber 2017].

Finally, the end-of-life factor that includes recyclability is another factor to consider. It is the ability of a material to be captured and separated from a waste stream for conversion or reuse. The environmentally-conscious consumer will consider a product that is able to recycle or reuse [De Aguiar et al. 2017]. The end-of-life of the product is important towards a resilient supply chain. Thus, the material used to manufacture the product should be able to be reprocessed and redefined for reuse or converted to new material after the product comes to end of life [Guzzo et al. 2020].

Analytical Hierarchy Process (AHP)

AHP is one of the most commonly applied tools in many fields. It is a decision-support method that can be used to deal with both quantitative and qualitative data. AHP consists of hierarchical structure objectives including the main criteria, sub-criteria, and alternative factors. It was introduced by Saaty in 1980. In this study, AHP uses expert judgments to identify medical devices that are worthy for product development. AHP is a supporting tool for decision-making that is used to solve complex problems [Improta et al. 2019]. Unal et al. [2021] proposed a new product development model in real estate by integrating data mining with AHP in market analysis. Henrique dos Santos et al. [2018] applied AHP in a bank to identify programs or services that the bank should offer to customers. Compared, Yang et al. [2020] used the AHP method to determine prioritization of customers' requirements by linking it to the NPD process. Furthermore, Gholizadeh and Fazlollahtabar [2021] developed a generic model for self-assessment in SMEs. In this field of study, numerous studies report on the successful use of the AHP method to identify and evaluating the key driving factors.

METHODOLOGY

AHP application

The AHP is a method of measurement through pairwise comparisons of factors, objects, or elements, which depend on the judgments of experts to establish priority scales [Hussain et al. 2015]. Comparisons are initially made by using an absolute scale of judgments that reveal how much more important one element may be than another. In addition, one element dominates another element concerning a given attribute. The AHP method is a multi-criteria decision-ranking process that enables the user to work with both tangible and intangible factors.

A) Hierarchy decomposition

AHP is a supporting tool to help break down this complexity. When it is applied in decision-making, it assists the authors to describe the general decision in operation by decomposing a complex problem into a multi-level hierarchic structure of objectives, criteria, sub-criteria, and alternatives. Hence, it enables the authors to easily find the optimal solution.

B) Pairwise comparison

Pairwise comparison required the authors to assume that the set of n objects which represent the alternatives among all of the criteria of the same level in a hierarchy are the set of weights, respectively. Consequently, the authors proceed to compare the weight of each object in the following form:

$$\begin{matrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \frac{w_1}{w_3} \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \frac{w_2}{w_3} \cdots & \frac{w_2}{w_n} \\ \frac{w_3}{w_1} & \frac{w_3}{w_2} & \frac{w_3}{w_3} \cdots & \frac{w_3}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \frac{w_n}{w_3} \cdots & \frac{w_n}{w_n} \end{matrix} \quad \Rightarrow \quad A = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \frac{w_1}{w_3} \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \frac{w_2}{w_3} \cdots & \frac{w_2}{w_n} \\ \frac{w_3}{w_1} & \frac{w_3}{w_2} & \frac{w_3}{w_3} \cdots & \frac{w_3}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \frac{w_n}{w_3} \cdots & \frac{w_n}{w_n} \end{bmatrix}$$

This is called the matrix of pairwise ratios

$$A = (a_{ij}), \quad a_{ij} = \frac{w_i}{w_j}, \quad i, \quad j = 1, 2, 3, \ldots, n.$$

in which

The coefficients of matrix A are defined according to the following rules:

a) If $a_{ij} = \frac{w_i}{w_j} = \alpha$, then $a_{ji} = \frac{1}{w_i / w_j} = \frac{1}{\alpha}$ in which $\alpha \neq 0$ and the possible value of $\alpha \in E =$ (1 to 9), E is the pairwise comparison scale shown in Table 2 below.

b) If w_i is as important as w_j, and then $a_{ij} = 1$, $a_{ji} = 1$. In particular, $a_{ii} = 1$ $\forall_i = 1, 2, 3, \ldots, n$. Therefore, the matrix of the pairwise comparisons for each pair becomes:

$$A = \begin{pmatrix} 1 & a_{12} & a_{13} \cdots & a_{1n} \\ \frac{1}{a_{21}} & 1 & a_{14} \cdots & a_{2n} \\ \frac{1}{a_{31}} & \frac{1}{a_{32}} & 1 \cdots & a_{3n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{n1}} & \frac{1}{a_{n2}} & \frac{1}{a_{n3}} \cdots & 1 \end{pmatrix}$$

which is called a reciprocal matrix.

Table 2. AHP pairwise comparison scale

Intensity	*Importance*	*Examination*
1	Equal	Two criteria have the same quality value.
3	Moderate	One is slightly more important than the other.
5	Strong	One is strongly more important than the other.
7	Very strong	One is dominantly more important than the other.
9	Extreme	One is extremely more important than the other.
2,4,6,8	Intermediate	When the comparison requires a compromise.

Note: Reciprocals of the above numbers when there is an inverse comparison [Source: Hussain et al. 2015]

The reciprocal matrix is the main matrix equation that essentially leads to the final answer. However, before reaching the goal of the answer, it is necessary to set the coefficients for each element of matrix A. To this end, a questionnaire is designed to allow experts to assign values concerning the scale shown in Table 2 above.

C) AHP solution

The authors now should proceed to consider a linear equation system. The aim is to look into how the solution of this equation appears by reason.

$A \cdot x = y$ in which $x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$ $\quad y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}$

To form this equation explicitly, it can be made in the form: $\sum_{j=1}^{n} a_{ij} \cdot x_j = y_j$, $i = 1, 2, 3, ..., n$. On the other hand, the equation $a_{ij} = \frac{w_i}{w_j}$ can be rewritten in a different form by simply multiplying both terms with $\frac{w_j}{w_i}$. As a result, the new equation looks like $a_{ij} \cdot \frac{w_j}{w_i} = 1$, $(\forall i, j = 1, 2, 3, ..., n)$. Then the authors are required to sum up this equation again with respect to j, and the whole equation becomes: $\sum_{j=1}^{n} a_{ij} \cdot \frac{w_j}{w_i} = n$ or $\sum_{j=1}^{n} a_{ij} \cdot w_j = n \cdot w_i$, $i = 1, 2, 3, ..., n$. This expression can take the form of $A \cdot w = n \cdot w$ as a linear equation. It can also be rewritten in the form of a matrix as shown below:

$$\begin{pmatrix} 1 & a_{12} & a_{13} \cdots & a_{1n} \\ \frac{1}{a_{21}} & 1 & a_{14} \cdots & a_{2n} \\ \frac{1}{a_{31}} & \frac{1}{a_{32}} & 1 \cdots & a_{3n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{n1}} & \frac{1}{a_{n2}} & \frac{1}{a_{n3}} \cdots & 1 \end{pmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix} = n \cdot \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix}$$

This matrix equation shows the concept that w is the vector of weights or priority vector and the main eigenvector of A, in which n represents the range of its value. Accordingly, this equation can be written in the form of $A \cdot w = \lambda_{\max} \cdot w$, in which $\lambda_1, \lambda_2, \lambda_3, ..., \lambda_n$ are n solutions of the eigenvalue. However, in the real practice of AHP, there is no value of w and λ. There is only the coefficient of the matrix A taken from the questionnaire. More complicatedly, there will be more than one expert making judgments in some special conditions. Although these things are inherent, Saaty [1980] recommended using the geometric mean when there are many experts. Therefore, the reciprocal matrix above develops as follows:

$$A = \left[a_{ij}\right]_{n \times n} = \begin{bmatrix} 1 & \sqrt[m]{\prod_{k=1}^{m} a_{12}} & \sqrt[m]{\prod_{k=1}^{m} a_{13}} \cdots & \sqrt[m]{\prod_{k=1}^{m} a_{1n}} \\ \frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{21}}} & 1 & \sqrt[m]{\prod_{k=1}^{m} a_{23}} \cdots & \sqrt[m]{\prod_{k=1}^{m} a_{2n}} \\ \frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{31}}} & \frac{1}{\sqrt[m]{\prod_{k}^{m} a_{32}}} & 1 \cdots & \sqrt[m]{\prod_{k=1}^{m} a_{3n}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{n1}}} & \frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{n2}}} & \frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{n3}}} \cdots & 1 \end{bmatrix}$$

Importantly, Saaty [1980] mentioned that a simple way to obtain an approximated solution is as follows:

1. Sum the value in each column of the pairwise matrix:

$$S_{ij} = \sum_{j}^{n} C_{ij} \qquad (j = 1, 2, 3, ..., n)$$

$$= (sc_{11}, sc_{12}, sc_{13}, ..., sc_{1n})$$

2. Divide each element in the matrix by each column total to generate a normalized pairwise matrix:

$$X_{ij} = \begin{bmatrix} \frac{1}{sc_{11}}\cdot 1 & \frac{1}{sc_{12}}\cdot\sqrt[m]{\prod_{k=1}^{m} a_{12}} & \frac{1}{sc_{13}}\cdot\sqrt[m]{\prod_{k=1}^{m} a_{13}} \cdots & \frac{1}{sc_{1n}}\cdot\sqrt[m]{\prod_{k=1}^{m} a_{1n}} \\ \frac{1}{sc_{11}}\cdot\frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{21}}} & \frac{1}{sc_{11}}\cdot 1 & \frac{1}{sc_{13}}\cdot\sqrt[m]{\prod_{k=1}^{m} a_{23}} \cdots & \frac{1}{sc_{1n}}\cdot\sqrt[m]{\prod_{k=1}^{m} a_{2n}} \\ \frac{1}{sc_{11}}\cdot\frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{31}}} & \frac{1}{sc_{12}}\cdot\frac{1}{\sqrt[m]{\prod_{k}^{m} a_{32}}} & \frac{1}{sc_{13}}\cdot 1 \cdots & \frac{1}{sc_{1n}}\cdot\sqrt[m]{\prod_{k=1}^{m} a_{3n}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{sc_{11}}\cdot\frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{n1}}} & \frac{1}{sc_{12}}\cdot\frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{n2}}} & \frac{1}{sc_{13}}\cdot\frac{1}{\sqrt[m]{\prod_{k=1}^{m} a_{n3}}} \cdots & \frac{1}{sc_{1n}}\cdot 1 \end{bmatrix}$$

3. Sum the value in each row of the pairwise matrix:

$$S_{ij}^{*} = \sum_{i=1}^{n} C_{ij} \qquad (i = 1, 2, 3, ..., n)$$

$$= \left[s^{*}c_{11}, s^{*}c_{21}, s^{*}c_{31} ... s^{*}c_{n1} \right]^{T}$$

4. Divide each row total by the n-dimensional of the matrix to get the weighted matrix:

$$W_{ij} = \frac{S_{ij}^{*}}{n} \quad (\forall i, j = 1, 2, 3, ..., n)$$

$$W_{ij}^{*} = [w_{11}, w_{21}, w_{31}, ..., w_{n1}]^{T}$$

D) Consistency evaluation

The main consideration for practitioners when the AHP method is applied is the notion of consistency. The method which involves the eigenvalues in the solution of the linear equation helps practitioners to quantify the distance for its condition of consistency. As a small variation in a_{ij} implies a small variation in λ_{max}, then the result of $(\lambda_{max} - n)$ can be taken as a measure of the consistency expressed in matrix A. The authors define the notion of the consistency index as the ratio:

$$CI = \frac{(\lambda_{max} - n)}{n - 1}$$

$$\lambda_{max} = (sc_{11}, sc_{12}, sc_{13}, ..., sc_{1n}).[w_{11}, w_{21}, w_{31}, ..., w_{n1}]^{T}$$

n dimension of matrix A

CI is compared with the random index (RI) that is randomly generated by forcing reciprocal matrices. When n ranges from 1 to 15, it is estimated as the average in a sample where there is an increasing number from 100 to 500. This experiment was performed by Saaty [1980]. As a result, the consistency index table is formed as shown in Table 3 below.

Table 3. Random consistency index

N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty 1980

The ratio:

$CR = \frac{CI}{RI}$ defines the consistency ratio (CR).

As an empirical rule grounded by Saaty [1980], if CR is less than or equal to 0.10, it is assumed that the quality of the comparison derived from the experts' judgments is acceptable. When judgments do not align with reason, the decision maker should be given the opportunity to have another quick review of the comparison for each pair.

Input data for the model

The application of AHP produces a set of factors and sub-factors, generally called sub-criteria. Comparison is made in order to choose the best selection. Data is collected from the interviews based on the questionnaire with the 15 participating experts. After the evaluation criteria have been accepted by the interviewees as appropriate, a questionnaire is developed to gather primary data, which are the pairwise comparison judgments between each pair of main criteria and sub-criteria and the performance scores of each factor under each criterion. The data gathered from the questionnaire is analyzed by applying the statistical method and the AHP model to find the relative importance level, weighted performance score under each criterion, and the overall weighted main criteria and sub-criteria performance score.

RESULTS AND DISCUSSION

The data collected from the 15 experts was then analysed using Microsoft Excel. Comparison is made in order to choose the best selection. The geometric mean is applied to get the common data. Afterwards, the authors proceed with the AHP calculations to deal with the factor's consistency. The final result of the AHP is the multiplication between the score of the sub-criteria and the main criteria as listed in Table 4.

Table 4. Final result of the prioritization

Main factor	*Sub-factors*	*Main criteria*	*Sub-criteria*	*Result*
Price	Affordable concerning quality	0.039	0.166	0.006
	High with respect to quality	0.039	0.834	0.033
Quality	Operating quality	0.273	0.124	0.034
	Speed	0.273	0.133	0.036
	Durability	0.273	0.226	0.062
	User-friendliness	0.273	0.217	0.059
	Energy saving	0.273	0.299	0.082
Service	On-time service	0.133	0.547	0.073
	Easy maintenance	0.133	0.453	0.060
Reliability	No toxic material released	0.275	0.252	0.069
	Safety and security	0.275	0.748	0.206
Appearance	Size	0.079	0.173	0.014
	Weight	0.079	0.141	0.011
	Portable	0.079	0.429	0.034
	Stationary	0.079	0.258	0.020
End-of-life	Recyclability	0.202	0.741	0.150
	Disposability	0.202	0.259	0.052

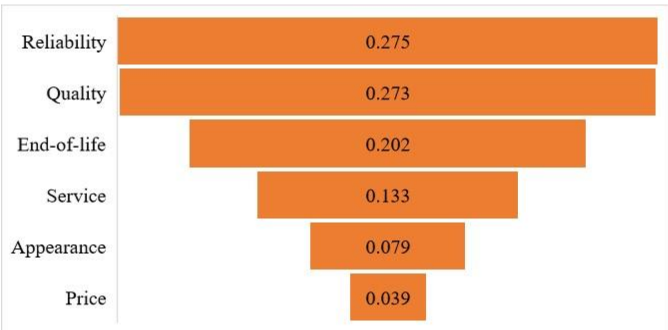

Fig. 1. Prioritization of main-criteria

Furthermore, the result shows that material selection is the highest priority among the other influencing factors. Follow by recyclability (0.150). This means that medical device users are concerned with the quality of the product not only for present use but also for the future of the product, which refers to after the end of its life. This is in line with the SDG agenda and is similar to a study done by Behera and Dash [2018]. In comparison, customers may not want the product to be disposed of (disposability=0.052). This means that they expect the manufacturer to ensure that the product can be recycled rather than disposed of. In addition, energy saving (0.082) is the third priority that product users find to be an important factor. Because sophisticated medical devices run on electricity, decent energy utilization may not only be able to save hospital expenses, nevertheless, it may also avoid triggered access when products are being operated at demanding times.

Moving forward, the value of 0.073 represents the on-time service. It refers to the service provided by the medical device company within both product delivery and after-sales service. Service delivery is critically important in hospitals because the product must be used to support patient lives and ensure adequate and effective processes in the healthcare business [Majchrzak-Lepczyk & Bober 2016]. Between the present use and after use of the product, safety and security (0.206) are more important than durability (0.062), user-friendliness (0.059), operating quality (0.034), and product speed (0.036). This contributes to the two factors of data quality and function quality. However, customers also demanded that all products should be able to function without having problems. If any unfortunate situation occurs, the product should be easy to repair or easy to maintain (0.060). Furthermore, if the product cannot be repaired, it is assumed that it will reach the end-of-life phase, which is required for disposal or recycling. This action also has an economic benefit for other businesses, such as product recycling businesses, where the refined material can be used to produce or remanufacture other high-quality products.

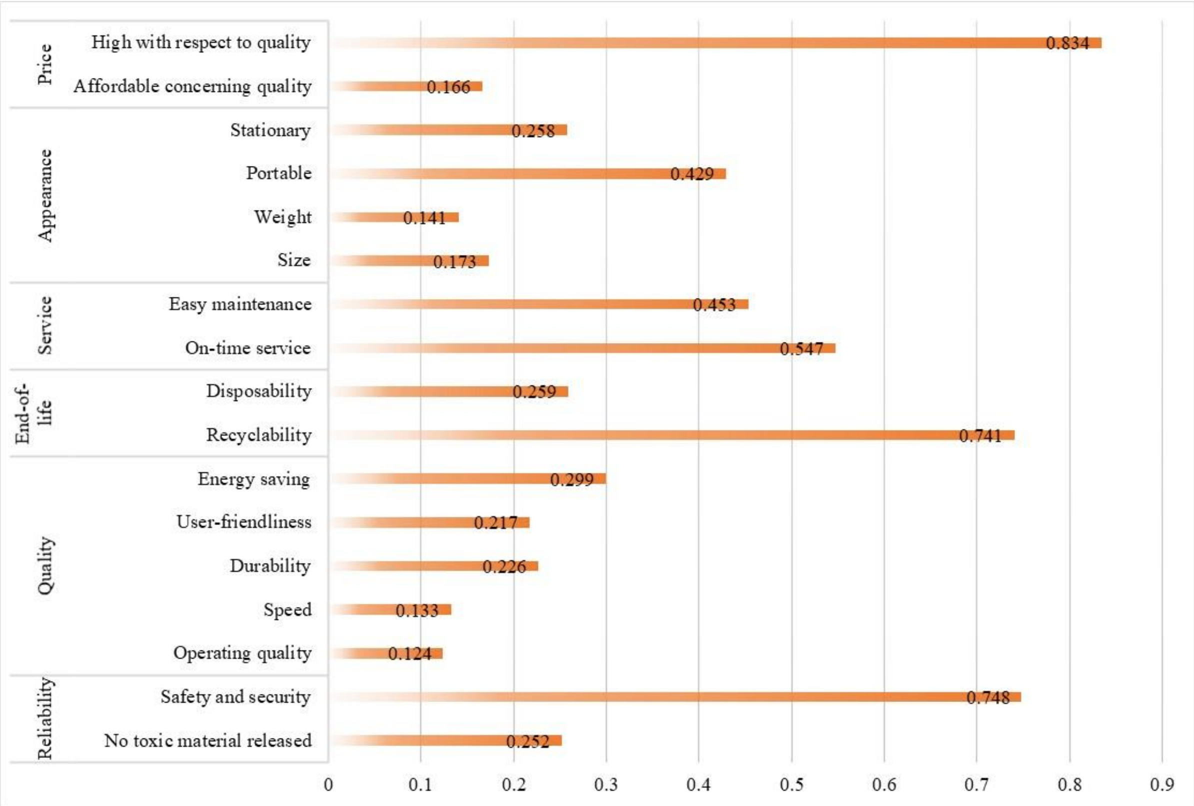

Fig. 2 Prioritization of sub-criteria

However, durability, operating quality and product speed are always in the user's mind. If the product is easy to use, the level of satisfaction continues at a high level, as exemplified in Figure 2. Among product appearance, being portable (0.034) has the highest value compared to stationary (0.02), size (0.014) and weight (0.011). A portable product is one that can be moved from one place to another. In the context of the healthcare sector, a patient may be moved from one place to another based on his condition. Therefore, it is necessary to be equipped with portable medical devices to avoid jeopardizing the patient's life. Stationery products can also be important given the complexity of some medical devices that cannot be moved, such as CT scanners and other diagnostic equipment. Note that a high price with high quality is more important than a low price with low quality. This is related to the devices being used by humans. Therefore, it is important to ensure that no risk is allowed when using the medical device [Weber 2020]. Even though the values of the above factors and sub-factors are arranged in descending order, they all play a role in ensuring the good quality of the product. These influencing factors will enable perceptions that can influence healthcare hospital procurement staff to rethink before deciding to buy medical products.

In the healthcare sector, patients need a sense of confidence and hope that the treatment service provided can improve or save their lives. To provide effective service, the hospital needs a set of skills ranging from skilled doctors and nurses to other related agencies, drugs, and technology. Green initiatives can also help to win public acceptance for hospital services. Furthermore, it also has the potential not only to save the planet, but also to enhance a business's bottom line. However, it takes much effort on the way to become an eco-friendly hospital. It involves many aspects such as green building design, energy efficiency, mode of transportation, food, water, waste management, and technology usage. Going green also involves optional things which can offer benefits to medical staff, patients, and the environment. Especially, being a green or sustainable hospital helps to increase the hospital's reputation and image.

CONCLUSION AND DIRECTION FOR FUTURE RESEARCH

Business can be created not just by operating in the way that an enterprise wants to, but it also has to pay attention to and the observe both the inside and outside environment. Therefore, collecting all the right information from stakeholder requirements and including them in the process is the engine of success. The product users and developers are two sides of the same coin that cannot be separated. The result of this study shows the growing awareness of sustainability in the healthcare industry towards a resilient supply chain. This means that designers are tending to take responsibility for using medical products that can reduce any side effects on the environment and conserve natural resource utilization. It is suggested that future research should be conducted using the Data Envelopment Analytic Hierarchy Process (DEAHP) approach. It is one of the most suitable solutions for possible influencing factors. This study helps to shed light for future researchers or those who are new in the field of medical products to turn their attention to conducting further research by taking into account the concept of sustainability toward the SDG agenda.

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