Factors Investigation for the Development of Medical Device towards Sustainable Product

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Abstract

Today healthcare service has offered the modern treatment approach with medical technology. This kind of technology has become such a predominant part of healthcare service because no practical diagnosis or treatment strategy is possible without using them. The advancement of technology is also driving medical companies with great opportunities to take a new innovative product into market. In addition, company could not focus solely on large amount of volume and low production cost to keep up growth, however, they have to control its direction towards quality trusted for usage. Meanwhile, climate change and pollution is increasingly unprecedented before and putting burdensome on this sector, which is lacking behind other sectors, to become sustainable manufacturing organization. That is true that medical device industry considers safety, usability and efficacy of product, but product design and development is a major role behind these factors. Sustainable design, sometimes called green design, has become a globally significance topic but not many works of academic papers are directly targeted to the medical device product. Therefore, the purpose of this study is initially conducted to identify influencing factors and then determine key improvement recommendation for sustainable development of medical device. Analytic Hierarchy Process (AHP) is used to prioritize the influencing factors and Quality Function Deployment (QFD) is used to find the key improvement attributes recommendation. The result of this study shows linear relationship between product user and developer towards quality and sustainability of product. It is found that the most of the top concerns of device users are not only safe for present use but also recyclability, which product can be made for environmental conservation, at the end of its life.

Keywords
Medical device, Sustainability, Product development, AHP, QFD

1. Introduction
One of the biggest industries in healthcare sector is the industry of medical device manufacturing. The industry is importantly driven by concept of innovation and new systematic discovery. For the last few decades, it has been seen that this industry has become an unprecedented growth due to the fact that there are interested investments in innovative technology advancement. According to research conducted by Lucintel (2018), the global medical device market is expected to reach approximately $410 billion by 2023. The major drivers of growth for this market rely upon healthcare expenditure, increasing of health awareness and boom of aging population. The medical device technology leads the way of healthcare much stronger than any other forces. Healthcare organization needs it necessarily to provide highly safety treatment service to the patients as they need emergency help. Although every medical device company probably has different standards level of defining quality product, it is normal sense that the high quality product is not simply sure that it is totally defect-free because there are many development processes being paid much attention on. As an example, customer value proposition, value creation and value capture. Evidently, products recall for medical device has taken place previously. Those products were sent back to company or supplier for field correction and repair (Zuckerman et al., 2011). When this kind of problem occurs, it is

likely that company tends to lose creditability and reputation. Meanwhile, climate change and pollution is increasingly unprecedented before. That is because of many factors among which residues from factory and usage of non-environmentally friendly product are integral part (Milfont et al., 2017). All of these changings results CO2 emission and hazardous substance which has bad impact on land quality, air and water that pose the consequence of biodiversity, human health and ozone depletion. Along with these, the healthcare hospital generally demands to procure and use a variety of products which it is one of a major source of environmental impact. On the other hand, there are increasing research activities on developing tools, techniques frameworks and application in the area of eco-friendliness, mostly on non-regulated product to help support or assist the firms (Kammerl et al., 2017) and also factors towards green or sustainable goal (Moktadir et al., 2018), not many works of academic papers are directly targeted to the medical device product. In 2015, Moultrie et al. (2015) conducted exploratory study to investigate a current performance of medical device company for their practice on product. The result has indicated a prosperous insight to reach green or sustainable point. The designers have prospective perception that the most significantly important way to implement design for environment (DfE) are in situation where they can directly control, specifically referred to product design and development at early stage. Environmentally friendly design, sometimes called sustainable design or green design, has become an interesting topic. From a designer or engineer's perspective, sustainable design takes the entire product life cycle into account that begins with creation concept to disposal. Sustainable product design is the key component of significant change in business operation. The impact of product on environment is determined within specification of development and concept generation, approximately sixty to eighty percentages (Robert, 2014). However, one of the major ways for business success that business organization could not neglect is to examine what stakeholder's requirement really is. Therefore, using techniques to entirely capture the stakeholders' needs and wants by integrating it into product design and development is crucial importance for product developers (Privitera et al., 2017). The stakeholders' voice help company turn keen eyes on product and production design in order for fitting demand needed

One of the most powerful tools is successfully applied in many fields; however, there is scarcity in medical device known as Quality Function Deployment (QFD). The Quality Function Deployment is created by Japanese professors named Yoji Akao and Shigeru Mizuno in the late 1960s (Akao, 2004).The essential approach of the Quality Function Deployment is to collect all voices of stakeholders ensuring that values are shared. QFD is an effective planning tool for product, service and process design and development, more importantly for both the radical and incremental creation of thing. So far, there are authors developing this tool from traditional one to sophisticated ones, for example, environmental perspective and cost is integrated in QFD process. In 2016, Moultrie et al. (2016) presented several tools to support medical device industry in design and development of environmentally friendly product such as Life Cycle Assessment (LCA), Eco-design, and Environmental Quality Function Deployment (EQFD), but the authors did not have any application of those tools. So Environmental Quality Function Deployment (EQFD) is going to be implemented as a main tool in this research for developing sustainable medical device product at the early stage. In addition, Analytical Hierarchy Process (AHP) is also used as the supporting tool of EQFD.

2. Literature review

Medical device is defined by as any instrument, machine, appliance, implant, in vitro reagent or calibrator, software, material or other similar or related article, intended by the manufacturer to be used, alone or combination, for human beings for one or more of the specific purposes including diagnosis, monitoring, and prevention of diseases. They are basically categorized based on risk essentially embedded with them. The classifications are specifically varied by country. The devices classified are prominently important in the marketing clearance application. A regulation of the medical devices in different regions is varied.

2.1. The new tendency on business industry

Medical device industry has been seen lagging behind other industries. Reason may be connected to the strict national and international dorms on which products are subjected to keep primarily in line with quality, safety standard, product efficacy and regulation guideline (Albino et al., 2009). It means that rigorous and restricted focus on those often makes company's efforts deprioritized or postponed in minimizing environmental impact. This may be hindered by cost pressure, lack of knowledge and resource to invest in environmental improvement, could not find starting point or those businesses may be struggling for survival within the short-term run (Moultrie et al., 2015). On the other hand, there are driving forces moving the industry towards sustainable design practicese like job employment which is demanded friendly environment in working place. Moreover, there will have effective growing legislative pressures on the medical device industry to eliminate or reduce the impact of waste and especially, hazardous or toxic substance. Evidently throughout the EU, all electrical devices are subject to (WEEE), (RoHs) and (REACH) directive. Medical devices can be exempt from this legislation only if they are expected to be ineffective as a result. In ASEAN, healthcare is being improved through medical device regulation harmonization of member states. Medical devices manufacturer has to design and manufacture by ensuring safe through selecting material usage, performance and material compatibility with tissue or cell of human body based on directive. This directive is expected to be the most effective very soon in near future. To do business in a contemporary environment, taking environmental practice helps to attract the eyes of stakeholders and shareholders. Adoption of sustainable practice in manufacturing industry enables business to stand in strong position that leads to long-term successful business. It also complies with regulatory requirement and gives opportunities for operating business.

2.2. Product development

Product development is the processes of creating the new product to market or improving the existing product with added features in which customers need are fulfilled. The innovative product development enables company to keep existing customer, attract new customer and reap competitive advantage. Traditionally, manufacturing practices have paid primary attention on product in the pre-manufacturing, manufacturing and use phase. That leads to much waste and landfill saturation. Along with a consideration of holistic approach at product, process and system levels, the implementation of sustainable practice in manufacturing industry by using a 6Rs methodology like Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture enables close-loop and aligns material flow over product lifecycle (Huang and Badurdeen, 2017). Aguwa et al. (2010) used an integrated fuzzy-based modular architecture for medical device design and development. The method was emphasized on assessing data input of stakeholder from existing products and components to obtain optimal number of modules. In general case, the design requirements of device are not easily understandable structure. The safety, quality and effectiveness of medical device are set during this phase such that the most important points of successful medical device product development are well-defined overall design. In fact, sustainable concept stems from "a kind of development that meets the needs of the present generation without compromising the ability of future generation to meet their own needs" (Brundland, 1987). Traditional product design focuses on product functionalities, quality and costs for meeting customer requirements. On the other hand, sustainable product design plans and stresses the importance of the entire life cycle from its raw material selection to end-of-life product.

2.3. Quality Function Deployment (QFD) and Analytical Hierarchy Process (AHP)

Quality function deployment is a planning tool for product and process improvement. It achieves through How of Quality (HoQ). The voice of customer (VoC) is a very essential factor in developing and producing product that will match and go beyond customer expectation. QFD is successfully applied in many cases, both alone and combination with other tools. On the other hand, the Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Professor Thomas Saaty in 1980. The AHP is a decision support tool which can be used to solve complex decision problems. Zadry et al. (2015) applied QFD to improve the design of long spinal board (LSB) in an attempt to establish better equipment compatibility and mobility when used, as the result, the evacuation process can be worked more safely, effectively and efficiently. Battistoni et al. (2013) used AHP methodology to define the weights of customer needs connected to NPD process of typical impulse buying goods, a snack. Managing new product development (NPD) becomes essential part for manufacturers, particularly small and medium-sized enterprises (SMEs) who try to survive in today's burgeoning marketplaces. The emerging issues of sustainability and green have become the main point of motivations to various government institutions, legislative bodies, industries, corporation and businesses in developing policy and making strategic decision. However, the QFD could not be used alone when some rooms of HoQ are of more than one sample size of data, especially in the room of VoC (Voice of Customer). Therefore, the supporting tool is usually needed. Anyway, to find the degree of importance of customer requirements is a challenging step in constructing QFD matrix. Even though there are many tools able to handle it, for example, data mining and arithmetic mean, but those tools require a big sample size of the data to reach a reliable point. To address these challenges, there are several researchers and practitioners have developed and suggested to use Analytic Hierarchy Process (AHP). For example, Nan et al. (2011) discussed the concept of AHP-QFD for new product development. An earphone development project is chosen as a case study. The AHP is applied to weigh customer requirements. The authors uncover that the AHP method is able to apply in a few other QFD elements. Applying Analytic Hierarchy Process in determining the degree of importance of customer requirement in Quality Function Deployment Matrix can provide a good framework for making decision on problem.

2.4. Sustainable perspective on product design and development

To produce a sustainable product that's just not only a product must fulfill with requirements. To this end, knowing those requirements at first is sure that the need will be made. From consumer perception, normally customer they first ask or look at price before deciding to buy product. However, they look into quality too. Comparison between product price and quality will automatically appear in customer's mind. The quality is the measure of excellence or state of being free from defect. There are not many customers that look into product quality before price (Dubey et al., 2013). The product quality is likely that customers attempt to focus on some importance such operating quality, speed, durability, user-friendliness, energy-saving (FDA, 2014). In addition, product delivery service is required on time; clear information and agile response are needed (Batista et al., 2013). This is included maintenance service when the product is downtime. Usage of product is step that reliability should be provided, which account for safety and security (Hei et al., 2015). Appearance of product is the outside look which attracts to the eyes ranging from size, weigh, portable and stationary. But when product could not be used any more, how can consumer handle with it? They keep in stock or throw it away so the concept of recyclability and disposability helps environment and prevent natural resource depletion (Singh et al., 2015). From producer perspective, the things are accounted for material, manufacturing, product usage and end-of-life product which they should be examined together in early step of product design and development (Ngatilah et al., 2018). Material selection is the next step after product concept design (Sastri, 2014). In phase of production, manufacturing which consists of hardware, software, firmware, power supply, packaging reduction (Sherman, 1998). When product is already made, service delivery and after sale service should be considered for example product toolkit for maintenance.

To sum up, this seed of ideas help to improve product innovation that it is not just only a product but also inherent in quality needed.

3. Methodology

The structure of this research methodology is designed as shown in Figure 1 below:

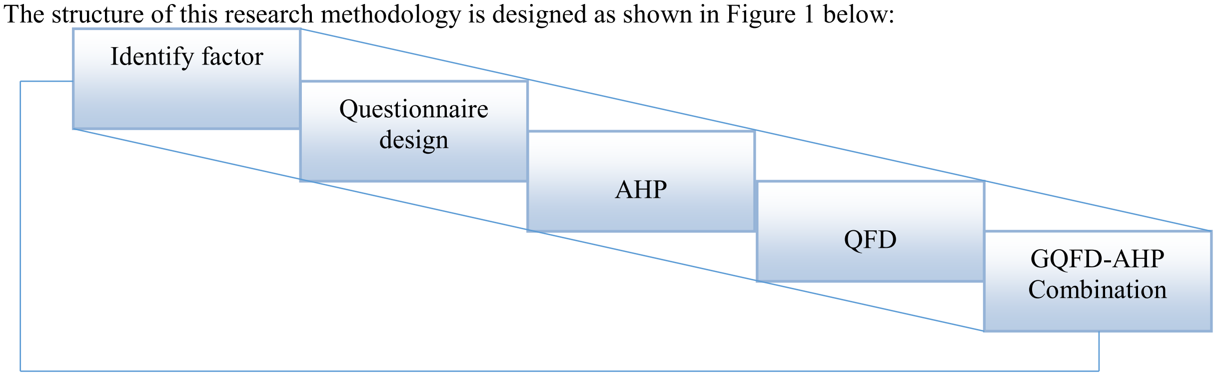

Figure 1. Research methodology

3.1. Source of reference

There are many ways to get factors from customer's voice and strategic attribute specification from product developer, although not all of them have the same result. However, this research is used four of strategies as they give more than enough information such as Brainstorming, Journal Article, Electronic Book, and Webpage.

3.2. Analytics Hierarchy Process (AHP)

An analytic hierarchy process is the theory of measurement through making pairwise comparisons between different things which it depends on the judgments of experts to select priority. The comparisons are made using a scale of absolute judgments that represents how one thing is much more important over another thing. Clearly mentioning, one element can dominates, be dominated or has the same quality of another element with respect to a given attribute. The AHP method is a multi-criteria decision ranking process that enables the user working with both tangible and intangible factors, for instance, preference, opinion, quality and number.

3.2.1. Hierarchy decomposition

Basically, to make good decision, we have to know information in problem. However, when problem is widely big, it makes decision-maker hard to take a point of releasing decision-making. AHP is supporting tool to help break this complexity. In AHP, the problem is necessarily divided into sub problems. When it is applied in decision-making, it assists us to describe the general decision in operation through decomposing a complex problem into a multi-level hierarchic structure of objectives, criteria, sub-criteria and alternatives. Hence, it drives us easy to find out the better solution.

3.2.2. Pairwise comparison

Let $A_1, A_{2,} A_3, ..., A_n$ be a set of n objects (could be alternatives or criteria) of the same level on a hierarchy element. $w_1, w_2, w_n, ..., w_n$ are weight of $A_1, A_{2,} A_3, ..., A_n$ respectively. We compare each weight of objects then we get matrix of pairwise ratio $A = (a_{ij}),\ a_{ij} = \frac{w_i}{w_j},\ (i, j = 1, 2, 3, ..., n).$ The coefficients of the matrix A are defined according to the following rules:

a. if $a_{ij} = \frac{w_i}{w_j} = \alpha$ then $a_{ji} = \frac{1}{w_i/w_j} = \frac{1}{\alpha}$ with $\alpha \neq 0$ and possible value of $\alpha \in$ E(1 to 9), E is pairwise comparison scale

Table 1. AHP Scale of comparison

Intensity	Importance	Description
1	Equal	Two criterion have the same quality value
3	Moderate	Slightly important one over another
5	Strong	Strongly important one over another
7	Very strong	Dominance of important one over another
9	Extreme	Extremely important on over another
2,4,6,8	Intermediate	When comparison is needed to compromise.
Reciprocals of the above numbers when there is an inverse comparison		

b. if w_i is as important as w_j, then $a_{ij} = 1,\ a_{ji} = 1,$ In particular, $a_{ii} = 1\ \forall_i = 1, 2, 3, ..., n.$ Therefore, matrix of the comparisons A is called a reciprocal matrix. The reciprocal matrix is the main matrix equation leading to final answer. However, before reaching goal, the thing needed to do is to set coefficients of each element of Matrix A. Typically, questionnaire construction, which contains 1 to 9 scales, is delivered to experts as shown in Table 1 above.

3.2.3. Consistency evaluation

An important consideration to be made when utilizing the AHP method is the notion of consistency. The method involving eigenvalues allows us to evaluate quantitatively the distance from condition of consistency. As small variation in a_{ij} imply small variation in $\lambda_{\max}$, the difference $(\lambda_{\max} - n)$ can be taken to be a measure of consistency of the evaluation expressed in matrix A. We defined the consistency index as the ratio: $CI = \frac{(\lambda_{\max} - n)}{n-1}$

CI is compared with the random index (RI) randomly generated for reciprocal matrices, with reciprocals forced, having n varying from 1 to 15 and taking into account the average on a sample having an increasing number of units from 100 to 500.

Table 2. Random of consistency index

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The ratio: $CR = \frac{CI}{RI}$ defines the so-called consistency ratio (CR).

An empirical rule supplied by **Thomas Saaty** states that CR of 0.10 or less is considered acceptable. When judgments are not far too coherent, decision makers should be given the opportunity to have another look at their pair comparisons. Through Supper Decision Software, it recommends user to adjust to reach consistency goal (Supper Decision Software**:** Go to Access/ compare => Pairwise Comparison => Matrix => Inconsistency report). Besides software, we can also calculate AHP by hand. The concept of AHP was developed from Linear Algebra which consists of weight of vector and eigenvector $(w \text{ and } \lambda)$. However, in the real practice of AHP, there is no value of w and λ. There is only the value of matrix A. More complicatedly, there will have more than one expert to make judgments. Anyway, Aczél and Saaty (1983) recommended using Geometric Mean when there are many experts. Saaty (1987) mentioned that a simple way to obtained an approximation is by normalizing the elements in each column (summation of elements in each column then dividing each element by its own column total) of the judgment matrix and then averaging over each row.

3.3. Quality Function Deployment (QFD)

QFD is a method for transforming customer requirements into strategic design and development with main purpose of fulfilling customer's needs. Through QFD methodology, company knows more clearly about its own capability to use resources in response to customers want.

House of Quality

The House of Quality is the most important tool in the QFD process. It collates all customers' information and describes real design parameters of engineering. This House of Quality is divided in many as shown in Figure 2.

In part I: Customer requirements (CR) (What)

This room is stored customers 'voice which normally has different preferences and requirement on product which they are willing to purchase. And it is initially asked with (What).

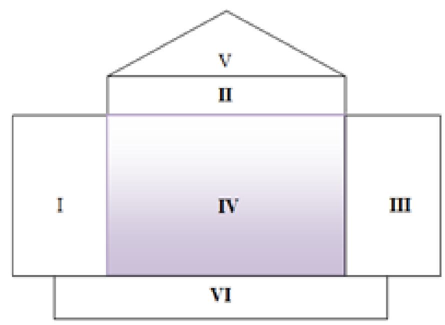

Figure 2. HoQ of QFD

In part II: Strategic Attribute Specifications (SAS) (How)

SAS should be meaningful, measurable and global. The parameter of each technical characteristic must have meaning to requirement demanded by customer. And it is initially asked with (How).

In part III: customer data prioritization W_{ij}^*

After all customers' voices are collected, the common average is determined for each row of customers' voices. That AHP is used to prioritize in this research work.

In part IV: relationship matrix (C_{ij})

Relationship matrix is made from co-relationship between CR and SAS that each relationship is able to be given a score to estimate to what degree SAS possibly has over the CR. To fill the gaps of the matrix relationship it is necessary to take into consideration the next question: "If we know the value for demanded quality of customer's requirement, how well it is predicted with strategic specification in order to satisfy customer's expectation?" To evaluate the range of importance for each intersection it has been used the three numbers typically used in these parts of the house of quality as shown in Table 3.

Table 3. QFD relationship matrix scales

Number	Description
0	No relationship
1	weak relationship
3	Moderate relationship
9	Strong relationships

In part V: Correlation matrix:

Correlation matrix is the relationship among SAS which has an effect on each other. The comparison is based on decision-maker of team who makes decision on trade-off value of those parameters. The correlation matrix is the least used room in the House of Quality. In this research, we are not going to use this kind of matrix due to resource constraint.

In part VI: The total score

The critical improvement specifications are shown. These values help company and engineering team improve on lacking points of requirement issue. The total score of the improvement specification is calculated with respect to $CIS = \sum (C_{ij} W_i^*)$.

3.4. Questionnaire design

The questionnaire is a structured technique for collecting primary data. It is a series of written or verbal questions for which the respondents are able to provide answers. The questionnaire is designed in different forms based on its application. In addition, a sample size is based on the area of the study and tool used, especially for the application of AHP and QFD. Even though there is no any specific evidence proved on its sample size; however, it's required the qualified experts who have knowledge and experience closely related to issue to team up with so that quality of AHP and QFD used is effective and efficient. About this research work, a formation is organized as below.

3.4.1. From customer part

After reviewing bases on source of references above and pilot interviewing with experts who has knowledge and experience of using medical device product, final result of influencing factors is found as listed in Table 4. These factors are constructed with respect to AHP-questionnaire form. After that it is delivered to 12 experts, who have knowledge and experience with medical device, to assign the value of comparison based on AHP by asking the question: "How more important do you think the criteria i compared to the criteria j?"

3.4.2. Technical part

There are two steps in this section for this research. The first step is to identify criterion related to customer aforementioned as shown in Table 5. The second step is to make sure that the requirements of strategic attribute specification from engineers perspective fits to those needs of customer, thus open-ended questionnaire is developed. The open-ended questions are questions that enable expert to give free-form answer concerning customer requirement. This form of the questionnaire will be brought to ask 6 experts who come from cross-functional department with related background knowledge of biomedical engineer, clinical engineer, mechanical engineer, electrical engineer and computer engineer.

3.5. Application

In this section, the application of tools is executed. The first application is given to AHP. The AHP is used to rank customer requirement that its data is collected by asking 12 experts. The final step is combination of result that AHP has and inter-relationship matrices of HoQ (House of Quality). Throughout QFD method, it makes a common point of voices between two sides of customer and developer. This leads to the point that improvement recommendation is shown for product vision.

3.5.1. Application of Analytics Hierarchy

The application of AHP comes up with comparing a set of factors and sub factors, generally called sub criteria. The comparison is made in order for choosing the best selection. In Super Decision Software, the arrangement is allowed to build as illustrated in Figure 3 in the next section. Since there are 12 experts who provide the questionnaire value, Super Decision Software is used to input one by one, in form of questionnaire built in software, from each expert. After all the values are input in Super Decision Software, then they are exported to Microsoft Excel. Geometric Mean is applied in order to get only common data. Finally, the result of Geometric Mean is export to input into Super Decision Software again. In the software, it is automatically calculated but AHP has to deal with consistency. Therefore, if the result is inconsistency, the a little adjustment is needed based on software recommendation. The final result of AHP is multiplication between the score of sub-criteria and main criteria as listed in Table 6.

Table 4. Voice of stakeholder

Voice of customer	Customer requirement	
F1: Price	CR.1	Affordable with respect to less quality
	CR.2	High with respect to good quality
F2: Quality	CR.3	Smooth operating quality
	CR.4	Speed
	CR.5	Durability
	CR.6	User-friendliness
	CR.7	Energy saving
F3: Service	CR.8	Quick response and on time service
	CR.9	Easily maintenance
F4: Reliability	CR.10	No toxic material released
	CR.11	Safety and security
F5: Appearance	CR.12	Size of product
	CR.13	Weight of product
	CR.14	Portable product
	CR.15	Stationary product
F6: End-of-life	CR.16	Recyclability
	CR.17	Disposability

Table 5. Definition of design requirement

1. Material	EC.1	Material reduction
	EC.2	No dangerous material
2. Manufacturing	EC.3	Hardware
	EC.4	Software
	EC.5	Firmware
	EC.6	Power supply
	EC.7	Package reduction
3. Service	EC.8	Time service
4. After sale	EC.9	Maintenance
	EC.10	Toolkit

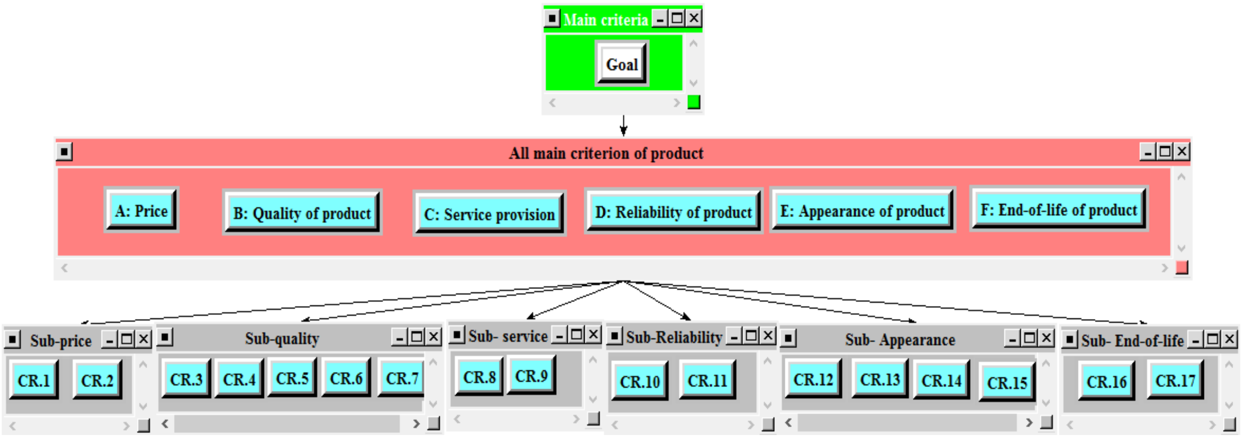

Figure 3. AHP model in Super Decision **Software**

Finally, the result is found as listed in Table below.

Table 6. Final result of prioritization

Main factor	Sub-factors	Main criteria	Sub-criteria	Result
Price	Affordable with respect to quality	0.039	0.166	0.006
	High with respect to quality	0.039	0.834	0.032
Quality	Operating quality	0.273	0.129	0.035
	Speed	0.273	0.123	0.034
	Durability	0.273	0.228	0.062
	User-friendliness	0.273	0.219	0.060
	Energy saving	0.273	0.301	0.082
Service	On time service	0.133	0.547	0.073
	Easily maintenance	0.133	0.453	0.060
Reliability	No toxic material released	0.275	0.748	0.206
	Safety and security	0.275	0.252	0.069
Appearance	Size	0.078	0.172	0.013
	Weight	0.078	0.140	0.011
	Portable	0.078	0.430	0.034
	Stationary	0.078	0.257	0.020
End-of-life	Recyclability	0.202	0.741	0.149
	Disposability	0.202	0.259	0.052

3.5.2. Application of Quality Function Deployment

In the final phase of using the main tool, QFD table collates all influencing factors from customers and engineers. The values given into cell of relationship matrix are average value since there are more experts of engineering who participate to assign in questionnaires. Importantly, the quality of product target is based on the knowledge that those expert judge. The result of QFD is the raw score which indicate strategic attribute specification to strategic improvement for product developer so that they can see what thing they have to innovate and add in order to reflect the need. That is beneficial for product planning and developing.

Table 7. Result of QFD

Engineering need / Customer need		EC.1	EC.1	EC.1	EC.1	EC.1	EC.1	EC.1	EC.1	EC.1	EC.1	Prioritization
F1	CR.1	6.000		6.667	5.667			3.667	8.000			0.006
	CR.2	5.167		6.667	8.000			4.500				0.032
F2	CR.3			6.200	7.000	7.000						0.035
	CR.4			3.200	5.500	5.500						0.034
	CR.5		7.667	5.667	3.500	4.500						0.062
	CR.6			2.000	4.500	3.667						0.060
	CR.7			1.667	5.000	3.667	7.000					0.082
F3	CR.8								9.000			0.073
	CR.9									8.000	9.000	0.060
F4	CR.10	7.000	6.500									0.206
	CR.11		6.667	5.667	6.667	6.667						0.069
F5	CR.12	4.667						3.000				0.013
	CR.13	6.667						2.833				0.011
	CR.14	5.667						2.167				0.034
	CR.15	5.333						1.333				0.020
F6	CR.16	4.167	4.333					3.000				0.149
	CR.17	4.667	4.667					4.333				0.052
Raw score		2.9	3.2	1.6	2.1	1.7	0.6	1.0	0.7	0.5	0.5	

4. Result and discussion

When we look at result from customer perspective, we can see that the most major voice is "No toxic material released value = 0.206". This result means that the customers also feel concerned about material selection from manufacturer or company who has made product. Importantly, when product is being operated with medicine or attached with human treatment. So that can be harmful to the patient. Another important thing is that they also have a good insight on last stage of product life in term of disposal and recyclability value, which is equal to 0.149. This means that environmental awareness is in an initial part of their thinking. Energy saving, due to patient is mobile, product equipped with battery is necessary to keep power for long that. In this case, it is not only beneficial for patient care but also economically reduce healthcare expense. On time service, service delivery which is provided by provider is an especial mark for customers due to their immediate need of product consumption. Safety and security: product safety and security is concerned with quality of product stemming from material component, software and security of data due nowadays most of medical product is embedded with Wifi signal and share data across functional department. So that healthcare process is on fast service delivery. However, data, kept and shared via network, must be ensured that there no any third party network inferences. Consequently, the patient's information will be lost as result that it will affect quality of patient care and the whole healthcare organization system. The lowest value is affordable price with respect to quality. Medical device is required high quality when operated with human. According to House of Quality (HoQ), the final calculation shows the range of strategic improvement. This result is a critically important for strategy and product developers to put their efforts on creating approach to innovate against the need. Noticeably, cross functional departments of engineers have focus on what customers are demanding that is correlated with sustainability arena. It is all about material selection. The material that there is no chemical substance that affects product life time and quality of use when it is operated for patient treatment. Material reduction: this is how engineers or company owner put discipline for product plan and development design. Careful planning makes company reuse scrap or residual and increase material value for finish product. Software: medical software is prominent for today technological use in healthcare organization system. This disruptive technology helps to improve healthcare service and improve the quality of care. The hardware, which is run by software, necessarily need power supply to fuel. Power supply: more than medical device alone, the device is equipped with power supply to support operating system run by motor or software and senor detect. Hardware: is made of raw material which refines to create tailored shape product. The combination of modularity of elements is the fit shape which all functions are operating in the right way at the same time. Packaging: the product packaging is another factor that material selection, will be used, should carefully consider. The light packaging is easy to carry or move to envelop main product and raw material reduction can save a lot of money for company. More than that, packaging product should be made of raw material that can be disposal or recycle to create new raw material for another product. This result, not only beneficial for economic benefit but also environmental health which there is no harm to biological life and human health. Maintenance and toolkit: is the last priority for engineer and manufacturer who should make consideration to produce for spare part and product repair when customers need those services. This key improvement recommendation will set aside of customer's dissatisfaction and also improve innovation effort as a system in company perspective. The company does not only lift up reputation but also officially comply with the law which ensures the prosperous action to the better world.

5. Conclusion

Business could be created not just only operate what company wants to do but also has to listen and observe both inside and outside environment. Product design and development play a central role for business manufacturing company. However, to get all collectively right information among stakeholder requirement and putting in the process is the sparkle of success. The product user and developer are two sides of the same coin which could not be separated away that this relationship is a bridge to keep business innovation alive. AHP and QFD are the powerful tools for user-centered design which can work best together with cross-functional teams; however, they require qualified set of experts who are specialized in solving problem. The result of this study shows sustainable perception in healthcare industry that they tend to take responsibility for using product which reduce side effect of environment and conserve natural resource utilization. On one plus side, the attributes improvement recommendations are the key pathway to reach sustainable product development goal, which material selection is a high priority among names ranged. Future research will be conducted to develop robust sustainable product design and development framework for medical device with case study, yet make interview with whom responses for product procurement and user. This research helps turn the light for researchers or the ones who are new in field of healthcare product to take their attention and boost their confidence to do further research by taking concept of sustainability.

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