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Functional Design Of Neonatal Intensive Care Unit Using Value Engineering And Quality Function Deployment Techniques

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Abstract: This paper deals with the integration of Quality Function Deployment (QFD) and Value Engineering (VE) in the Neonatal Intensive Care Unit (NICU) planning process. Quality function Deployment enhances the product/service performance on the basis of customer's requirements, whereas Value engineering focuses on the reduction of product/service costs without decreasing its quality or performance. The integration of QFD and VE both will lead to the decrease of costs and improvements of product/service or performance. In this paper firstly a conceptual idea of integrating these two techniques is provided and after that its implementation procedures are described in detail. The integration of quality function deployment and value engineering was analyzed in the product planning process. For this aim a conceptual model was developed. The application stages were also clarified. In fact the planned Model was an QFD & V.E integration ,in which the whole QFD process is not completely implemented rather its first two phases ,that is the product projection and product planning are carried and a list of results along with their value is got from the house of quality. The V.E process is not implemented completely either, rather the solutions and their relative values are entered from the second quality house into the second phase of Value engineering .During the design stage, lot of information is gathered and analyzed to back up the decision making process which will lead to the synthesis of products. The objective of the paper is focusing on mainly two things. Firstly, I seek to take the QFD and VE methodology one step further and apply it to propose a stakeholder-based design for the NICU facilities. Secondly, I demonstrate the outcomes of the QFD and VE methodology in the NICU design. I have started with the NICU not only because of its importance but also for its complexity which makes it a challenging quest. I have then implemented the House of Quality (HoQ) methodology in order to obtain an improved design over the existing ones. In doing so, I have made use of some of the most commonly used international standards (IS). This paper intends to give a more balanced review of Quality Function Deployment and Value Engineering that shows enough depth to be valuable to researchers as well as enough scope to provide for the readers.

Index Terms **- Neonatal Intensive Care Unit, Value engineering, Quality function deployment.**

I.INTRODUCTION

As India endeavors towards accomplishing its commitments to the SDG 2030 goals of decreasing neonatal mortality to at least 12 per 1000 live births, there is a need to reexamine our techniques/strategies to deliver accessible and quality newborn care, particularly in secondary- and tertiary-care health facilities. While there have been increased financial commitments for physical infrastructure, health facilities in India, especially in the public sector, are confronted with the challenge of giving quality maternal and newborn care in the face of major skilled human resource deficiency. Given the number of stakeholders and functional significance of hospitals, a well-designed Neonatal Intensive Care Unit (NICU) has the potential to improve developmental outcomes and reduce chronic illness . (Chellani, Mittal & Arya, 2018). The physical relationship between its various functions determines the configuration of any department in hospital. Thereby, it expresses the invincible importance for a hospital space to be designed providing highest value at the lowest cost. (White, Smith & Shepley, 2013)

Quality Function Deployment (QFD) improves the product/service performance based on the customer's requirements, whereas Value Engineering (VE) focuses on the reduction of product/service costs without reducing its quality or performance(Yegenegi, Arasti & Mousakhani, 2011). QFD and VE integration together leads to the decrease of costs and enhancements of service /product or performance. Providing value addition to Neonatal Intensive Care Unit (NICU) is of great importance and needs research on the same. Also, knowledge on value engineering, quality function deployment and its application are an essential knowledge addition to a project manager professional.

1.1 Aim

To apply the integration of Quality Functional Deployment (QFD) and Value Engineering (VE) techniques for the Neonatal Intensive Care Unit (NICU) in hospital building to arrive at a decision for best functional design which can adapt to the future needs"

1.2 Objective

1. To develop an understanding of Value Engineering (VE), Quality Function Deployment (QFD) and its concept of integration.
2. To develop an understanding of (Neonatal Intensive Care Unit) NICU department planning in detail and identify the parameters for the functional design of NICU department.
3. To develop a framework to analyze and evaluate the NICU design using VE and QFD tools and techniques.
4. To recommend the findings in the selected case study.

1.3 Scope

- The study will document all aspects of Value engineering and Quality function deployment and it application.
- The study will deal with the NICU planning and its design. The functional analysis and evaluation of the NICU department will be done using the selected methods/tools.

1.4 Limitation

- The study will document all aspects of Value engineering and Quality function deployment and it application.
- The study will deal with the NICU planning and its design. The functional analysis and evaluation of the NICU department will be done using the selected methods/tools.

1.5 Research Methodology

The research methodology used in this study is shown below in Figure 1

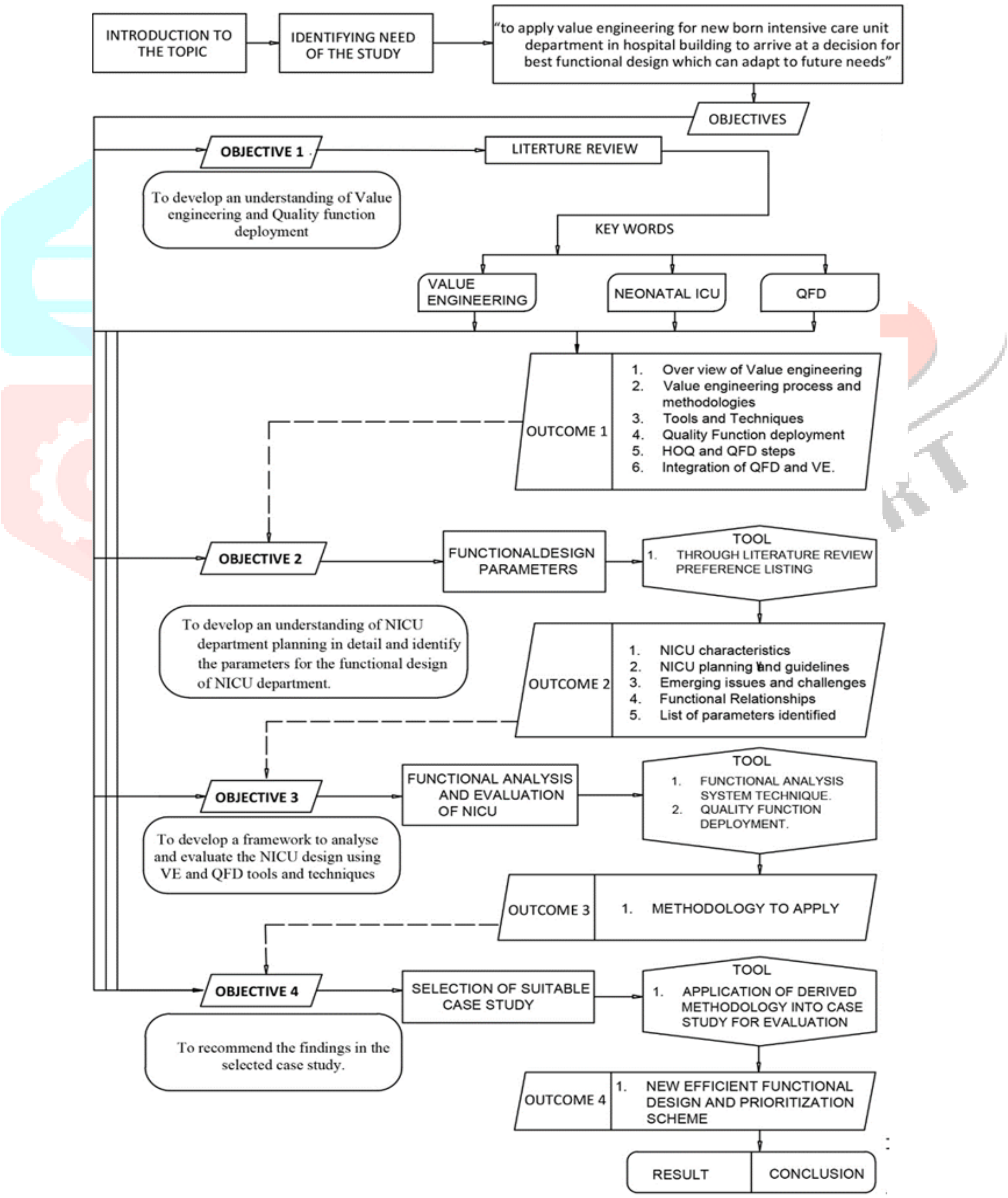

Figure 1: Methodology adopted for this study;(Author)

II. LITERATURE REVIEW

2.1 Value Engineering (VE)

According (Prof. Nitin L. Rane, 2016) to For the purpose of accomplishing the essential functions at the minimal total costs over the life cycle of the project, Value Engineering(VE) is an innovative and systematized effort, which examines the requirements of a project. According to (Yegenegi, Arasti & Mousakhani, 2011) Value Engineering(VE) and Quality Function Deployment(QFD) have various direction. Quality Function Deployment (QFD) is after more profit through more sales which are acquired by expanding the customers' satisfaction, whereas Value Engineering (VE) focuses on profit increase through cost reductions without bringing down the quality of the product. From the study it is seen that value engineering (VE) is a powerful problem-solving tool that can decrease costs while keeping up performance and quality requirements. After analyzing the process of Value Engineering, the importance of different stages involved are found out. The functional analysis process and evaluation process are taken for detailed analysis because of their importance in doing the construction evaluation of NICU building design.

2.1.1 History of Value Engineering

During the application of function analysis techniques to the component parts of a production in response of lack of skilled labor, raw materials, and component parts during World War II, Value engineering started at the General Electric Co. at the point when Lawrence Miles conceived Value Analysis in 1945.
Karl Marx's 1865 lectures also offer a first definition for value and particularly for a commodity, obviously in a standard of his days (it is considered by the modern economists obsolete by the theory of marginal utility.(Mesbah, 2014)

2.1.2 Value Engineering –Job Plan

The value engineering study utilizes a systematic method called job plan. The VE study is made out of of six phases: information phase, Functional analysis phase, creative phase, evaluation phase, development phase and presentation phase. All phases and steps are performed consecutively.(Senay Atabay & Niyazi Galipogullari, 2013)

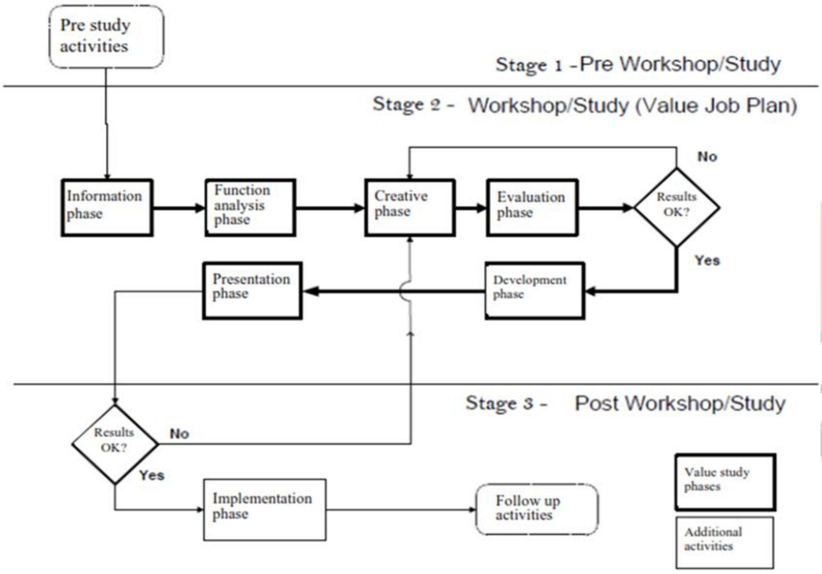

Figure 2: The Job Plan;(Senay Atabay et al,2013)

2.1.3 Value Engineering –Tools and Techniques—FAST Diagrams

FAST diagrams give a graphical representation of how functions are connected or work together in a system to convey the intended goods or services. Functions might be performed by the process, product or system, into a How? /why? relationship.

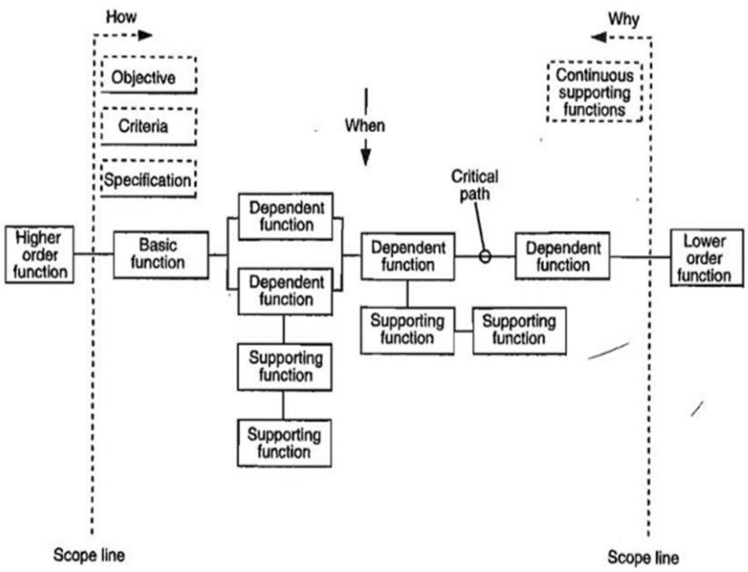

Figure 3: A sample of FAST diagram (Mesbah, 2014)

2.2 Quality Function Deployment (QFD)

According to (Gunnam & Eneyo, 2016), The reconciliation of Quality Function Deployment (QFD) and Value Analysis (VA) into your product improvement process helps in building up the products that clients need and value, described as Quality/Cost. According to (Paul & Seth, 2017) Quality Function Deployment (QFD) has been utilized as a tool for benchmarking. For the improvement of the framework and benchmarking, the case example of the technologies promoted by Government of India for "Housing for All" Mission has been taken up. According to (Annappa & Panditrao, 2013) QFD is used to develop processes including quality management to get new product design and development, It is vital for entrepreneurs to improve the quality of their products. Quality Function Deployment improves the product/service performance based on the customer's requirements. From the perspective of the user and customer it can empower the developers of these products to view cost reduction.

2.2.1 History of Quality Function Deployment

The idea of QFD was created in Japan in the late 1960s. After World War II, Japanese organizations used to duplicate and imitate product development; nevertheless, they chose to move their approach to one dependent on originality. To clearly study Quality Function Deployment (QFD) in 1978,the Japan Society of Quality Control shaped a research group for this.(Akao, Y., 1990)

2.2.2 QFD Methodology and The House of Quality (HoQ)

QFD is applied in the start stages of the design phase so that the customer wants are combined into the final product. A Comprehensive QFD may provide four phases which are as follows:

1. Product Planning (House of Quality); which translates customer needs/requirements into product technical requirement to meet them.
2. Product Design; which translates technical requirement to key part qualities or systems.
3. Process Planning; which identifies key process operations necessary to achieve key part characteristics.
4. Production Planning /Process Control; which establishes process control plans, maintenance plans, training plans etc to control the operations.

The Quality Function Deployment technique integrates building one or more matrices known as quality tables. and " The initial matrix is known as the "House of Quality" or (HoQ). The House of Quality matrix shows the customer's needs or (VoC) on the left-hand side, and the technical response to addressing the requirements along the top-hand side.(Delgado-Hernandez, Bampton & Aspinwall,

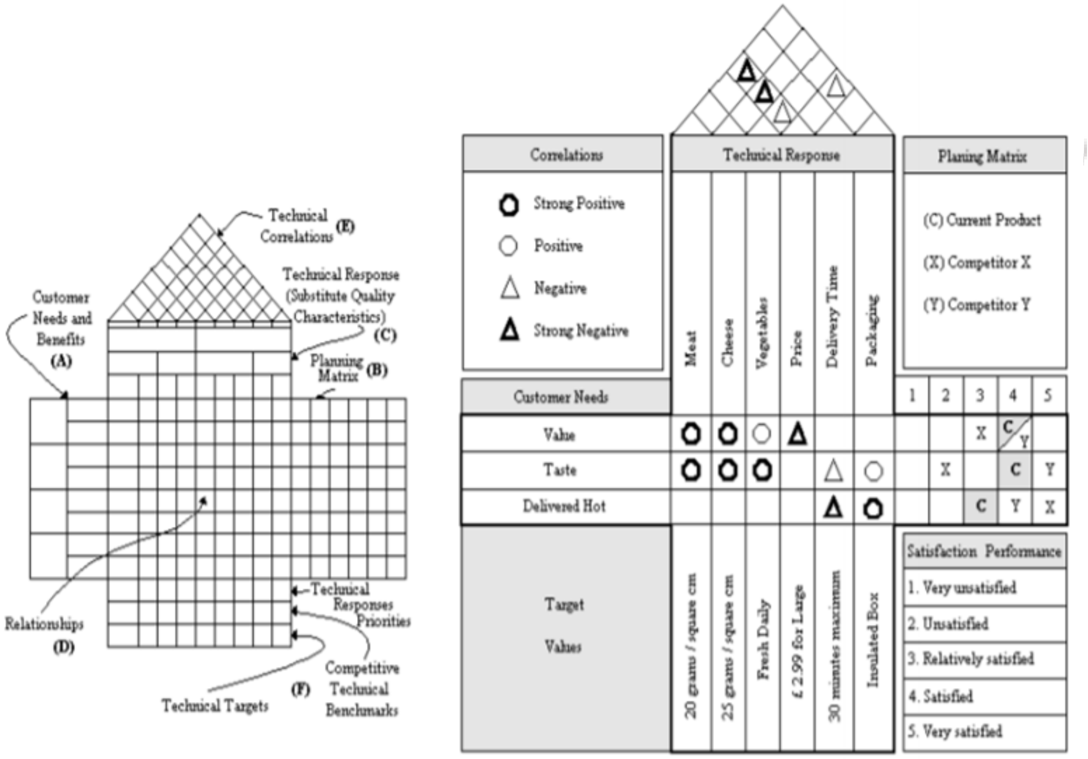

Figure 4: The House of Quality; (D.J. Delgado & E.M. Aspinwall,2007)

2.3 Neonatal Intensive Care Unit (NICU)

According to (O'Callaghan, Dee & Philip, 2019),'Single-family room' design for neonatal units is suggested and an ideally designed NICU has many possible health implications, including improved breastfeeding rates, infection and noise control, reduced length of stay and hospitalizations and possibly improved neonatal morbidity and mortality. According to the literature from(Massaro, 2005),he proposes that environmental control is important for neonates growth. They include 1) acoustical control; 2) lighting control; 3) infection control; 4) temperature control; 5) privacy, and 6) security. He also suggests to afford privacy and environmental control for the advantage to infants, the Single-family rooms may be the best setting to afford privacy and environmental control for the advantage to infants. Literature centers around the recent patterns and research of environmental factors in the NICU and their effect on the newborn infants, their family, and healthcare staff. The design of the NICU is multi-layered, since the environment affects the premature infant as well as the healthcare staff which, in turn, influences the infants. A proficient and sustaining physical environment is critical for the support of premature infants, their families, and the healthcare staff that take care for them.

2.3.1 NICU Design and Space Division

Conventional NICU designs have fluctuated from open rooms supporting 10-50 incubators to smaller rooms with four-to-eight station units, isolated either by walls or cubicle curtains. NICU is divided into two main categories-patient care areas and the ancillary areas. Patient care areas include the following spaces which are NICU Main area, Step Down unit, Neonatal ward, Isolation room and Triage room. The ancillary areas include the following which are Teaching room, Hand washing and gowning area, Nursing Work station, Fluid preparation area, Space for X-ray, Stores, Side laboratory, Breast feeding room, Doctor's room, Nurses room, Sister in charge's room, Washing, drying and autoclave, Out born mother's room, Sluice room, Janitor's chest, and Clean utility/ Holding area. (Rybkowski, Shepley & Ballard, 2012).Table 1 shows the area requirements of the NICU design and space division adopted from ICMR 2005

Table 1: Minimum space requirement in NICU, (Author)

SPACE	AREA REQUIRED	DESCRIPTION
Main NICU	1600sq.ft (for 16 bed unit)	Main NICU should have at least 12 -16 beds, which would cater to the sickest child in the Hospital. The main NICU area must be separated into two interconnected rooms (600 - 800sq.ft for each) detached by clear observation windows.
Step Down Unit	Unit -550 sq. ft (for 7-8 bed unit)	An additional 6-8 bed Step down Unit where recovering neonates can stay.
Neonatal ward	1100 sq. ft (for 18-20 bed unit)	This is an additional 15 - 20 bed, where both the mother and the newborn can stay together for neonates who require minimal support.
Triage Room	160 sq. ft.	2 warmers and all equipment's for neonatal resuscitation should be present. Triage room facility is intended for preliminary assessment and emergency administration of out born babies.
Side laboratory	100 sq. ft	The side lab should have a 2 ft wide concrete slab, 3 ft from the floor all around the lab for placing the equipment.
Store Room	75-100 sq. ft	First , second and third storage areas
Washing, Drying and Autoclave room	75-100 sq. ft	Space for commercial grade washing machine and a dryer should be accommodated.
Nurses' work Station	100 sq. ft	Within the Main NICU
Within the Main NICU	250 sq. ft	As a shelter for out born mothers who would require to be present at close proximity of the NICU to facilitate supply of breast feeding.
Nurses' Room	100 sq. ft	
Doctor's Room	100 sq. ft	
Teaching and Training Room	400 sq. ft	With every unit there should be a room allotted for teaching and training.
Sister-in-charge's Room	50 sq. ft	
Room for breast feeding and learning mother craft	100 sq. ft	It acts as mini Breast milk Bank for the facility as well as a space for expiration of breast milk by breast pumps.
Neurodevelopment clinic	650 sq. ft	
Sluice room	50 sq. ft	Sluice room will comprise a water reservoir with both inlet and outlet. Least dimension will be 4ft.wide x 3ft.front to back x 2ft. deep.
Clean Utility/Holding Area	50 sq. ft	Clean utility area is for storage of supplies frequently used in the care of newborn
Total Space Requirement	**9000 sq. ft**	

The concepts on NICU design were collected from the guidelines of the (1)Recommended standards for newborn ICU design, eighth edition,(Journal of Perinatology)(White, 2006) , (2)Toolkit for Setting Up Special Care Newborn Units(ICMR)(Indian Council of Medical Research [ICMR, 2005.), (3)SNCU Toolkit(NCRC & Dept of neonatology IPGMER ,Kolkata)(NCRC, 2011.), and (4)European standard of care of newborn health. The standards given in the tables are relevant for setting up a NICU in a district hospital or in an equivalent facility. While many of these details/specifications are "minimums", the intent is to optimize assets/resources and encourage quality health care for the newborn babies. In the following table 1,2 and 3the minimum space requirement and the specifications are listed out reffered from ICMR,2005

Table 2: Environmental characteristics of NICU, (Author)

CHARACTERISTIC	REQUIREMENT	CONCERN
Reflectance	Reflectance should be less than equals to 40%	
Gloss value	Gloss value <30 gloss units to minimize glare.	
Acoustic characteristics	• Background sound should not be more than 45 db • Peak intensity should not be more than 80 db	• speech intelligibility • normal or relaxed vocal effort • speech privacy • Physiological stability • uninterrupted sleep
Temperature	The temperature inside the main SNCU should be maintained at (26˚- 28˚C),	• Round the clock by thermostatic Control
Humidity	Relative humidity of 30 % – 60% should be maintained while avoiding condensation on wall and window surfaces.	
Ventilation	Minimum of 6 exchanges/hour with 2 changes being outside air	• Duct air conditioning system • All forms of noxious fumes and vehicular exhaust

Table 3: Specifications of different areas of NICU,(Author)

AREA	OPTIONS	CONCERN
Walls	Glaze tiled up to a height of at least seven feet	• Ease of cleaning • Durability • White or off-white color only. • Walls near hand washing sink of nonporous material. • Acoustical properties considered.
Ceiling		• Easily cleanable • White or off-white color only.
Floor	• Vitrified tiles • Kota Stone or chip flooring(well-polished) • Stain resistance • Rubber flooring(latex-free) in specific areas	• Easily cleanable • Highly durable • Minimize the growth of microorganisms
Handwashing area		• They shall be large enough to control splashing and designed to avoid standing or retained water. • Minimum dimensions 24 inches wide /16 inches front to back /10 inches deep (61 x41 x 25 cm3) from the bottom of the sink to the top of its rim

Figure 5: Sample design of NICU, adapted from design of NICU at satna district hospital, M.P (UNICEF ,2009.)

III. LIST OF PARAMETERS IDENTIFIED.

After literature review from almost 15 sources the parameters that are to be appraised for the application of Value engineering and Quality Function Deployment in Neonatal Intensive Care Unit is selected. The 12 parameters has been selected from four main categories namely environment, size, security and safety under two main quality dimension which are performance and features.

Table 4: Final list of parameters classification;(Author)

PRODUCT QUALITY DIMENSION	REQUIREMENTS	DETAILED REQUIREMENTS
Performance	Environment	Temperature in rooms
		Ventilation Daylight
		Daylight
		Acoustics (noiseless)
	Size	Space in patient room area
		Space for storage
Features	Security	Controlled access
		Monitoring visitors' arrivals
	Safety	Supervision of babies
		Design of babies

IV.FUNCTIONAL ANALYSIS OF NICU

Functional analysis is what distinguishes value engineering from all other similar techniques and has enabled it to survive for fifty years as a recognized optimization and improvement method. It is a key component of value engineering. It forces a broader and more comprehensive understanding of the project by stimulating intense discussion and by compelling team members to view the aspects they might not have normally considered. Function is the basis of value engineering. Functional analysis is the fundamental step involved in the study.

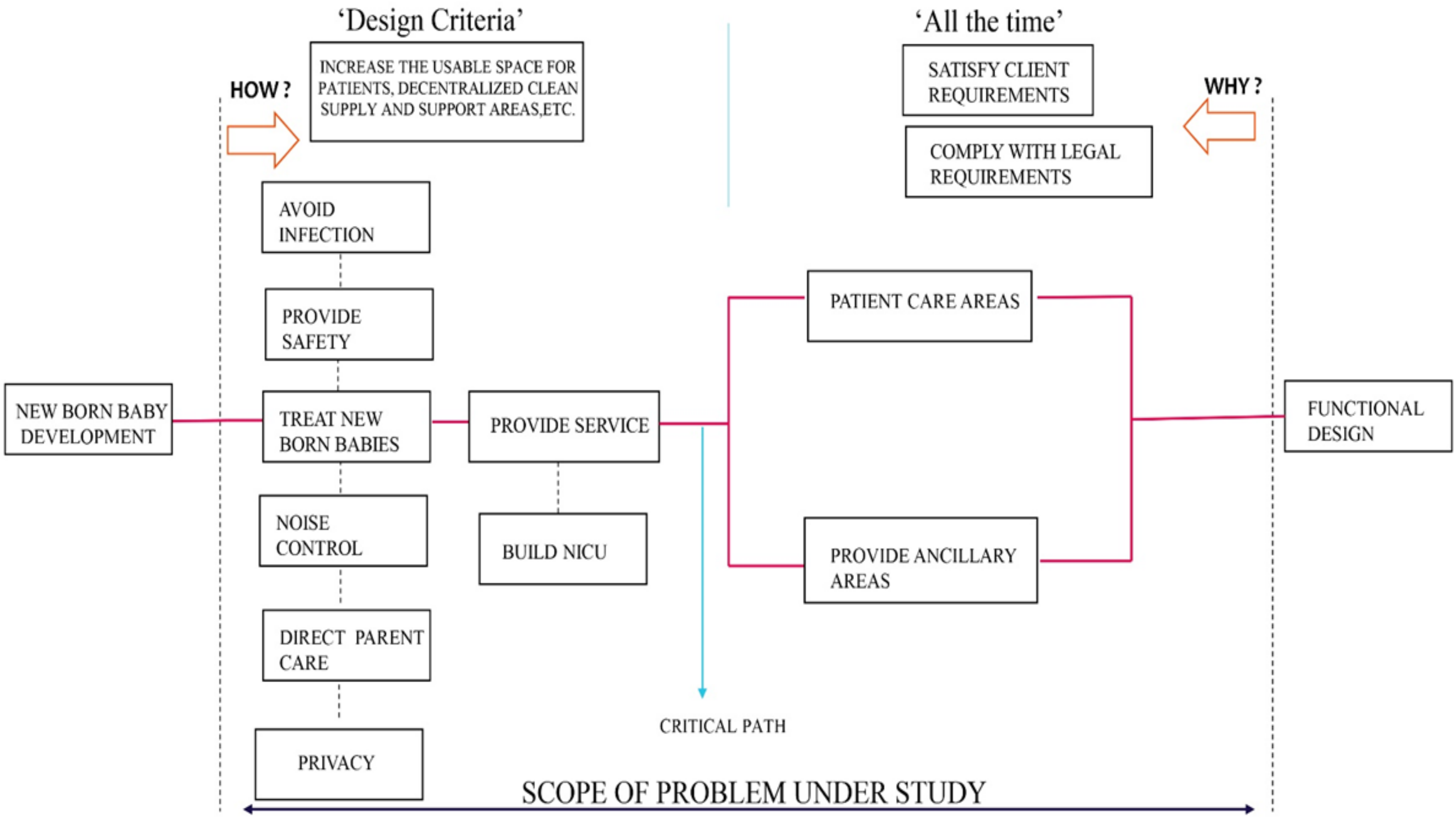

Figure 6: FAST diagram for the NICU department; (Author)

V. QFD AND VE INTEGRATION FRAMEWORK

The principle purpose of incorporating the methods of QFD & V.E in the design of service/product or production process is the determination of appropriate choices which while lead to the increased value for the customers and don't increase the service/product (Yegenegi, Arasti & Mousakhani, 2011)

The process of service/product planning based on QFD and VE principles is as follows

1.Firstly the customers' needs and requirements are considered.

2. The solutions or the alternatives adding to the materialization of these requirements are distinguished.

3. Then those solutions/alternatives which have a higher value index for the customers are chosen using the V.E technique.

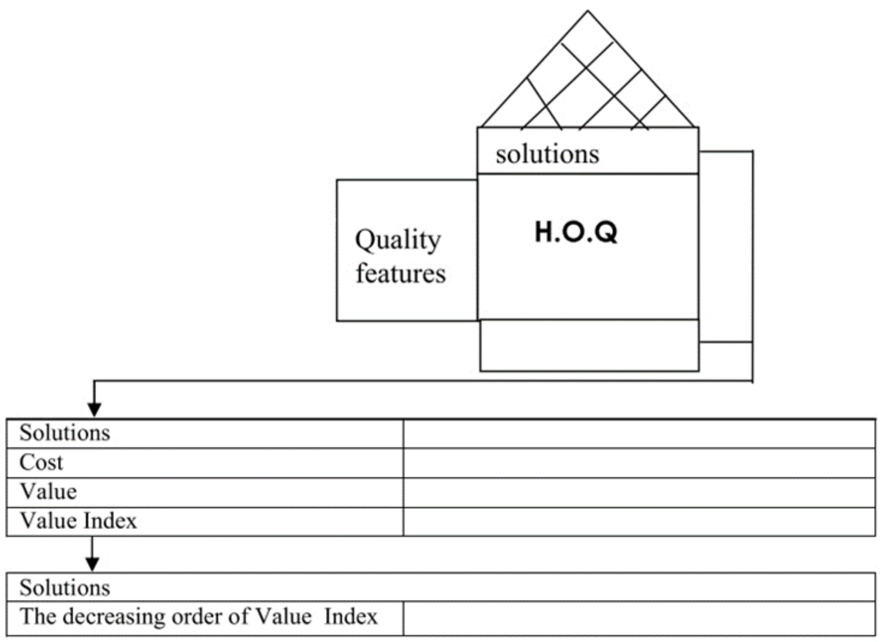

Figure 7: Relation between H.O.Q and V.E (adopted from Yegenegi, Arasti & Mousakhani, 2011)

VI. MATERIALS AND METHODS

The NICU stakeholders were asked to rate the questionnaire items based on a 5-point Likert importance scale for the survey.
1 = not important,
2 = slightly important,
3 = moderately important,
4 = important, and
5 = extremely important.
The data collected from questionnaire survey were analyzed using RII method.
The survey is conducted among NICU stakeholders. Stakeholders are NICU staffs and affiliated professionals who are linked to NICU (e.g., physicians, nurses, administrators, pharmacists, Non-NICU physicians etc.)

6.1 Questionnaire Survey Data Analysis

For survey, I classified the survey items into four groups, namely, (1) Environment, (2) Size, (3) Security (4) Safety. The survey was then conducted for 1 month among 32 NICU stakeholders, all of whom at the time of the survey were working in India

GROUP	Demanded Quality Requirements	Total No.	1 - Not important (%)	2 - Slight important (%)	3 - Moderately Important (%)	4 - Important (%)	5 - Extremely Important (%)	TOTAL (%)	RII	RANK
Environment	Temperature in rooms	32	0%	3%	22%	44%	31%	100%	4.0	4
	Ventilation Daylight	32	0%	3%	28%	44%	25%	100%	3.9	5
	Daylight	32	0%	6%	19%	38%	38%	100%	4.1	3
	Acoustics (noiseless)	32	0%	3%	13%	31%	53%	100%	4.3	1
Size	Space for family.	32	0%	6%	19%	56%	19%	100%	3.9	4
	Space for storage	32	0%	3%	31%	59%	6%	100%	3.7	5
Security	Controlled access	32	0%	3%	34%	47%	16%	100%	3.8	4
	Monitoring visitors' arrivals	32	0%	6%	22%	41%	31%	100%	4.0	2
Safety	Supervision of babies	32	0%	0%	31%	47%	22%	100%	3.9	2
	Design for babies	32	0%	6%	9%	47%	38%	100%	4.2	1

Table 5: Questionnaire survey data analysis; (Author)

6.3.2. The Construction of the HOQ

The QFD-based NICU design process seeks to identify and prioritize the NICU functional units based on both stakeholder requirements (SR) and international standards (IS). This Quality Function Deployment-based design is found through the following steps.

1. Filling the customer requirements and Technical Characteristics.

All the customer requirements summarized in 'Table 4:Final list of parameters classification;(Source: Author)'were put into room A or the "demanded quality features" or the "planning or design matrix" or the "What's" column of the HoQ and the Room D is filled with the "Quality characteristics" or "Technical requirements" or the "How's". This step is to translate the Customer Requirement into relevant Technical requirements based on (1) international guidelines, and (2) review of the literature.

2. Construction of the Relationship Matrix.

The core of the QFD technique is the relationship matrix. This matrix maps the correlation between demanded quality and technical requirements. Here the 3-point ordinal scale ("weak", "medium," and "strong") creates the values of the relationship matrix by means of series (1, 3, and 9). In this QFD-based method, we used the linear interval scale as (1 = low, 3 = medium, and 9 = high). A correlation value reflects how a design specification supports the purpose of a particular demanded quality requirement.

3. Construction of the Correlation Matrix (Roof).

This matrix or network shows how the design specifications support each other to distinguish the bottlenecks and exchange-off. A three-point scale has been used in this study in which ++ represents strong positive correlation, + represents positive correlation while -- represents a negative correlation.

Table 6: Demanded quality and Technical characteristics, (Author)

DEMANDED QULAITY/ PLANNING OR DESIGN MATRIX (WHATS)	TECHNICAL CHARECTERISTICS/REQUIREMENT (HOWS)
Temperature in room	Number of radiators
Ventilation	Number of air conditioning units
Daylight	Area of external windows
Acoustics (noiseless)	Finishes (floor, walls, ceiling)
Space for family	Acoustical absorption area
Space for storage	Acoustic seals for doors and building
Supervision of babies	No: of filters
Design for babies	Glazed external windows area
Controlled access	Family entry and reception area
Monitoring visitors arrival	Single family unit area.
	Storage area
	Number of doors with swipe cards
	Number of CCTV
	Number of sharp edges and projections
	Glass doors area

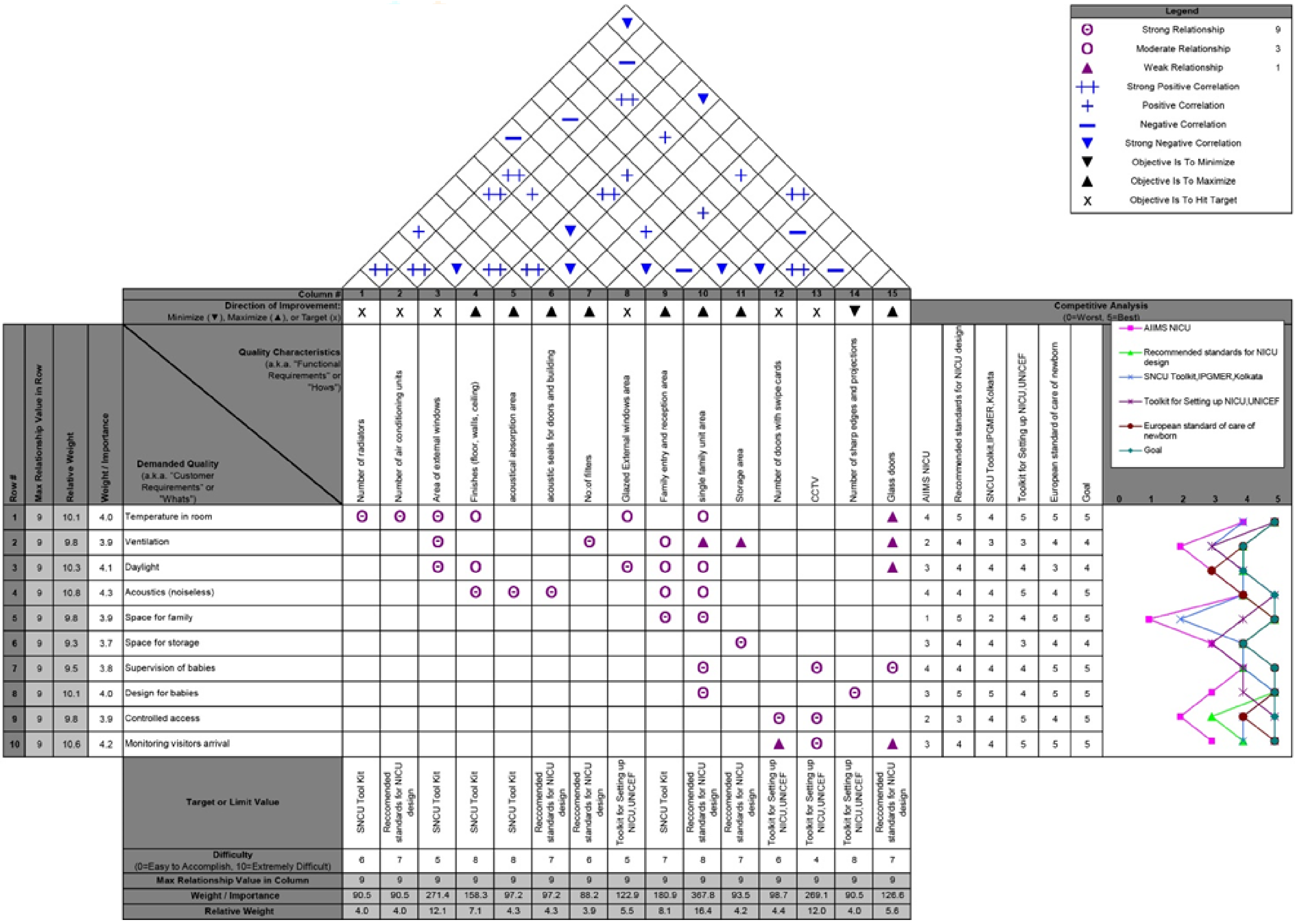

Figure 8: Complete QFD Chart;(Author)

VII. CASE STUDY

AIIMS hospital has been taken for the case study. Here AIIMS-Delhi has been taken for the analysis Case study is evaluated using the methodology evolved for applying the integration of quality function deployment and value engineering. This case study evaluation is necessary to test the accuracy of the evaluation methodology developed in this seminar work. This chapter of seminar work deals primarily with the explanation of the case study design and analysis of the same. Evaluations of the case studies are also done in this chapter. The scope of this seminar paper is to evaluate NICU design based on the criteria which will be derived for applying the QFD. Different spaces and circulation area has been calculated and compared with the standards for developing the planning matrix.

Figure 9: NICU Floor plan analysis - AIIMS, New Delhi. (Author)

VII. ANALYSIS

Here in the analysis part includes all the matrices used for planning the assessment of features of existing products against those of the standards available. We modified this matrix to make the QFD methodology more suitable for NICU design. The matrix includes the spaces of each service according to the existing design, and recommendation of standards, namely, Recommended standards for NICU design, eighth edition,(Journal of Perinatology), Toolkit for Setting Up Special Care Newborn Units(ICMR) UNICEF, SNCU Toolkit(NCRC & Dept of neonatology IPGMER, Kolkata), European standard of care of newborn. From that, it is found that AIIMS is lacking in the space for families, ventilation requirement and controlled access to rooms. As can be seen, acoustics and monitoring visitors were highlighted as the most important characteristics for the NICU. Temperature control and ventilation were deemed to be crucial especially during the summer with reference to security, the main customers' anxieties were related to controlled access within the NICU and monitoring visitors' arrivals.

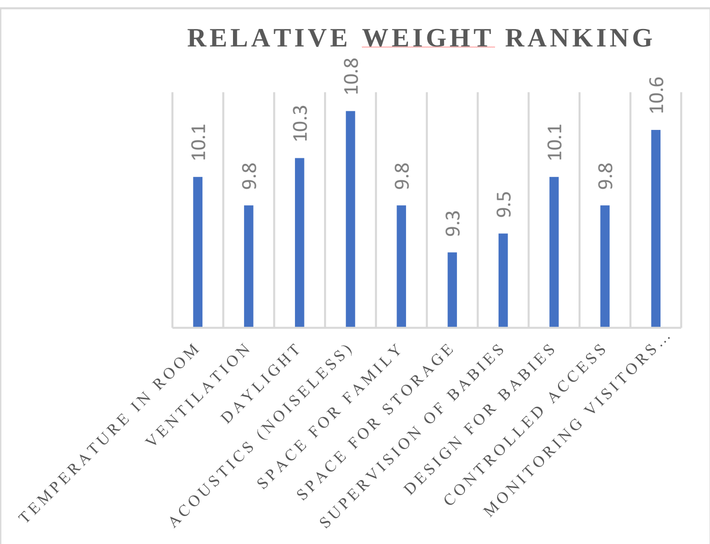

Figure 10: Showing the relative weight ranking; (Author)

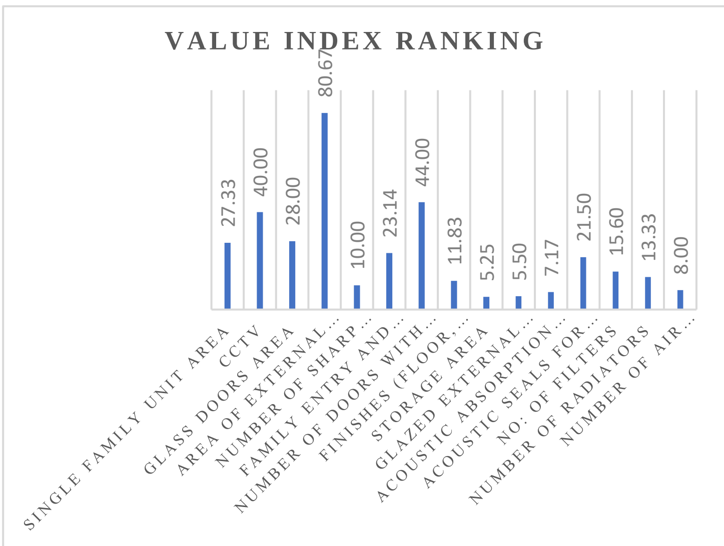

Figure 11: Value index ranking graph; (Author)

Table 7: Showing the matrix with the Demanded quality Requirements and its Relative weights (Author)

Quality Requirements.	Stakeholder Importance (From RII)	Improvement Ratio- (Goal/AIIMS performance)	Absolute Weight (RII * IR)	Relative Weight (A.W/∑A.W)	Rank
Temperature in room	4.0	1.25	5	10.1	4
Ventilation	3.9	2	7.8	9.8	5
Daylight	4.1	1.3	5.3	10.3	3
Acoustics (noiseless)	4.3	1.25	5.4	10.8	1
Space for family	3.9	5	19.5	9.8	5
Space for storage	3.7	1.33	4.9	9.3	7
Supervision of babies	3.8	1.25	4.75	9.5	6
Design for babies	4.0	1.66	6.64	10.1	4
Controlled access	3.9	2.5	9.75	9.8	5
Monitoring visitors arrival	4.2	1.66	6.97	10.6	2

Cost issues were included in the technical matrix, unlike the conventional HoQ, to ensure that it did not merely comprise a wish list. The approach suggested by Wasserman (1993) was utilized for the analysis. The relative weights were then calculated.

Table 8: Showing the matrix with the Technical characteristics, Cost factor and it Relative weights (Author)

Technical characteristics	Units	Absolute Weight (∑Tci * Rwi)	Relative Weight (AW/∑AWi)	COST (Per unit)	COST FACTOR (C/Cmax)	VALUE INDEX I/C	RANK Value index	RANK Relative weight
Single family unit area	m2	367.8	16.4	495000	1	27.33	5	1
CCTV	Number	269.1	12	2600	0.3	40.00	3	3
Glass doors area	m2	126.6	5.6	19294	0.2	28.00	4	6
Area of external windows	m2	271.4	12.1	14470.5	0.15	80.67	1	2
Number of sharp edges and projections	Number	90.5	4	38588	0.4	10.00	11	12
Family entry and reception area	m2	180.9	8.1	33764.5	0.35	23.14	6	4
Number of doors with swipe cards	Number	98.7	4.4	9647	0.1	44.00	2	8
Finishes (floor, walls, ceiling)	m2	158.3	7.1	57882	0.6	11.83	10	5
Storage area	m2	93.5	4.2	77176	0.8	5.25	15	11
Glazed external windows area	m2	122.9	5.5	96470	0.6	5.50	14	7
Acoustic absorption area	m2	97.2	4.3	57882	0.6	7.17	13	9
Acoustic seals for doors and building	m2	97.2	4.3	19294	0.2	21.50	7	9
No: of filters	Number	88.2	3.9	24117.5	0.25	15.60	8	15
Number of radiators	Number	90.5	4	28941	0.3	13.33	9	12
Number of air conditioning units	Number	90.5	4	48235	0.5	8.00	12	12

As can be seen, the five most important technical characteristics at this stage were: Single-family unit area, No of CCTV, Area of external windows, Family entry and reception area, and Finishes of Floor, Wall and Ceiling. The costs per unit (websites were employed to get meaningful data for this purpose) for each of the technical characteristics were then taken into account, owing to their relatively low cost, Number of doors with swipe cards, Area of external windows, gained priority.

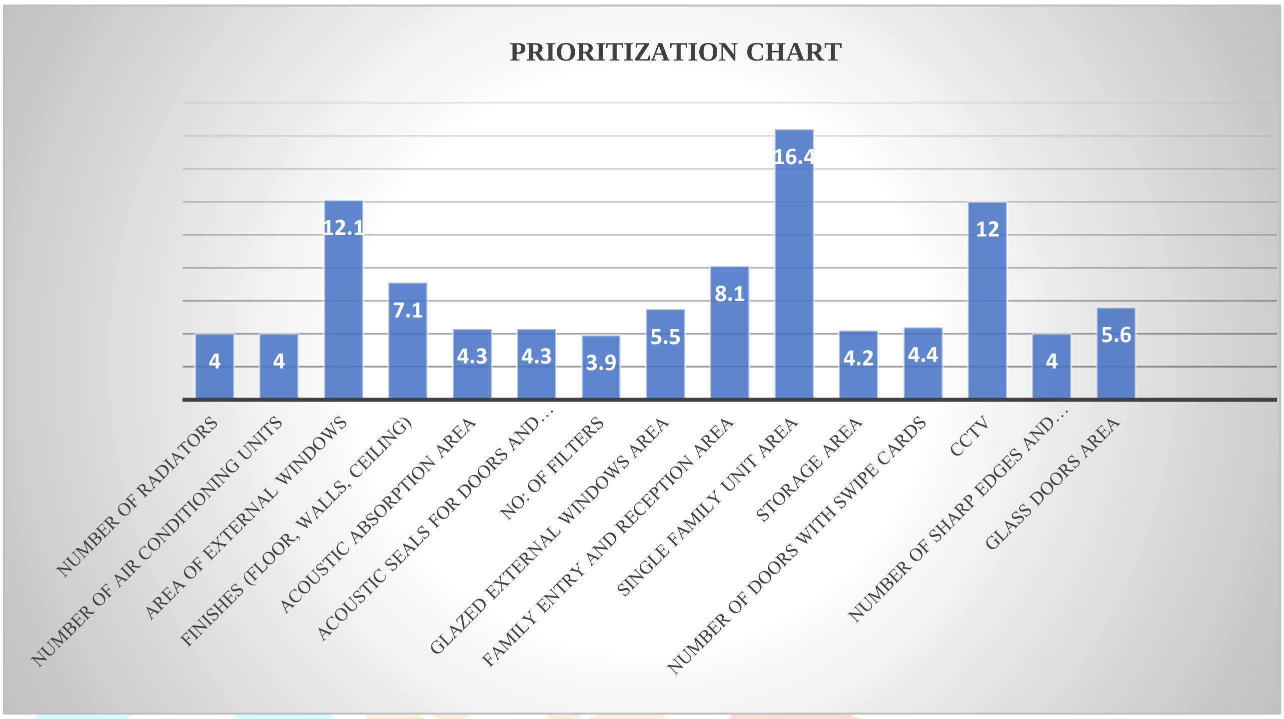

Figure 10: Prioritization chart of the technical characteristics;(Author)

Here a group of technical characteristics was proposed to fulfill the needs, and their relationship with each one of the agreed customer requirements. Costs were then analyzed to prioritize them. The five most important technical characteristics to design into the NICU were Increased family space by single-family unit area, Daylight requirement, Supervision of babies using CCTV, family entry and reception area and finishes in the wall floor and ceiling for acoustic and illuminative qualities.

VIII. RECCOMENDATIONS

1. Finishes selected and used ought to have acoustic and illuminative reasonableness, as well as for considering for infection prevention and where conceivable, be environmentally sustainable. Limit exposure to noise.
2. Support areas for families is also significant.
3. 'Single-family room' plan/design for neonatal units is recommended
4. Family cenetred care might be accomplished independently of neonatal intensive care unit design, if the environmental design allows privacy and protects from visual and auditory stress, the health benefits of daily parent participation, interaction, and skin-to skin care are altogether improved.
5. The environmental control is important for neonates' growth 1) acoustical control; 2) lighting control; 3) temperature control.
6. Provision of a remote camera system for patient observation for to reduce the risk of infant abduction.
7. Equipment formed 66% of the establishment cost. A significant cost reduction may be achievable by reducing the imported part of equipment.
8. The administration needs to adopt the most significant technical requirements that are achievable within their capacity and procedure/strategy.

IX. CONCLUSION

In this paper, an attempt has been made to develop a NICU department quality function deployment model. The aim was to modify the QFD application and apply it in NICU. Quality Function Deployment is an important and entirely adaptable tool for design. The relationship/correlation matrix is the core of the QFD process and store exact information needed for design improvement improves the product/service performance based on the customer's requirements, whereas VE centers around the reduction of product/service costs without bringing down its quality or performance aspects. The QFD and VE integration together leads to the reduction of costs and upgradation of product/service or its performance.

The exercise and results came across in the paper not only permitted the identification of the stakeholders, their most significant needs and the most relevant technical characteristics for satisfying them but it also enabled a serious examination to be performed that featured potential improvement areas. A better comprehension and knowledge of stakeholder needs/requirements for the NICU was therefore attained. The novelty and usage of the technical specifications such as this will depend on both the designers' creativity/imagination and the budget which is available to be spend. The value engineering exercise and QFD exercise finally concluded that finishes, mechanical and electrical components could be normalized across projects to reduce costs and provide value for money.

X. FUTURE SCOPE OF WORK

The model has been developed specifically for NICU department only. With a similar methodology, the model can be extended in to other detail departmental level analysis of hospital building. The same methodology can be used with different set of parameters to create a self-assessment tool for the service providers. The wide literature that had been referred to has many parameters that is of concern. The ranking matrix helps to find out the areas of value deficit and those areas where there is a large scope for value improvement can be taken up for future analysis. Separate future work shall use in the further phases of QFD to focus on the identification and prioritization.

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