CHAPTER 6

Allocation of weight to HCWM barriers and policy recommendations to overcome barriers

This study's barriers highlighted in the previous chapter were separated into four sub-sections: organizational, Waste handling, human resources, and technical. The weights of these barriers are determined using the AHP. Before identifying the consequences of the four subsections, each barrier's weight that fell within that subsection was also determined. When treating medical waste properly, the heavier barrier must be considered initially. The second step of this study involved the proposal of strategies to address the problems associated with healthcare waste management and the final rating of these options.

6.1 AHP Method:

The analytical Hierarchy Process (AHP) is used to determine the identified barriers' priority and importance. The AHP is a Multi-Criteria Decision Making (MCDM) technique used for evaluating the weight and ranking of the importance of decision-makers judgments. AHP was popular in solving complex decision problems. Different steps are used in the application of AHP, which are described below in Figure 6.1

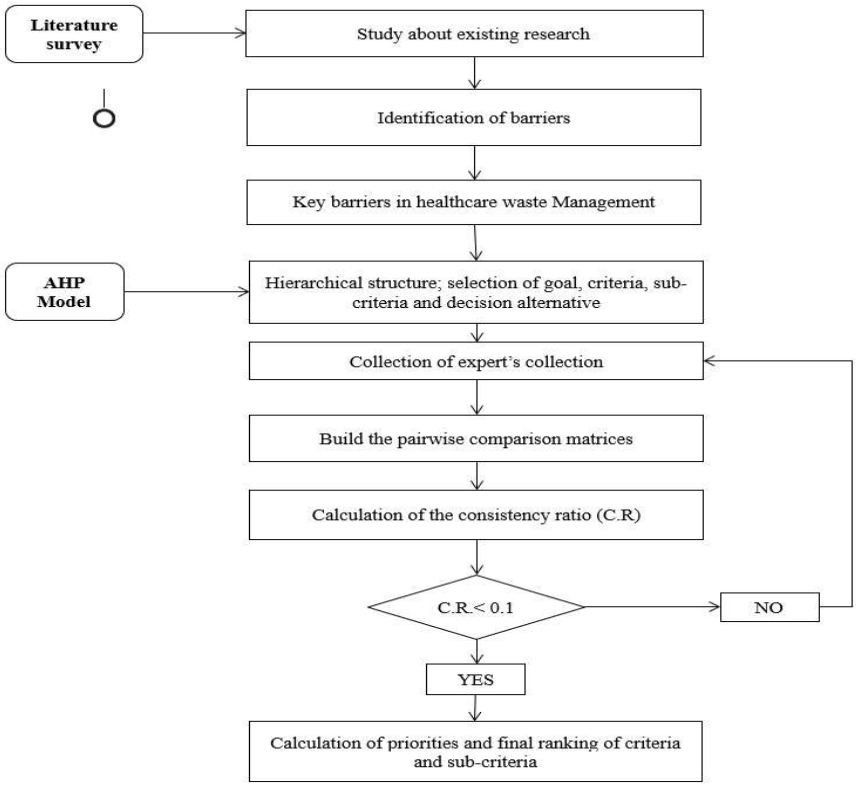

Figure 6.1: Flow Chart for AHP

Step 1: By listing the overall goal, criteria, and decision alternatives in a hierarchy, the process begins.

Step 2: By comparing each pair of criteria and sub-criteria, which is more essential and critical, they are assigned numeric values which range from 1 to 9.

The Scale of Relative Importance:

Preferences in numeric values	Preferences in linguistic variables
1	Equal importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2,4,6,8	Intermediate Values

Step 3: Construction of the pairwise matrix:

	A_1	A_2	…	A_n
A_1	1	a_{12}	…	a_{1n}
A_2	$1/a_{12}$	1	…	a_{2n}
….	…	…	…	…
A_n	$1/a_{1n}$	$1/a_{2n}$	…	1

Where A_j (j =1,2…, n) is the set of criteria, and a_{ij} (i, j = 1, 2…, n) is the quotient of weights.

Normalization of the matrix can be done by using Eq. (1):

$a^*_{ij} = a_{ij} / \sum_{i=1}^{n} a_{ij}$

Relative weights can be calculated by Eq. (2):

$w_i = \sum_{j=1}^{n} a^*_{ij} / n$

Step 4: Find the weighted sum value: By multiplying weights with the pairwise matrix elements and adding them row-wise, we will find the weighted sum value (WSV).

Where λmax is the largest eigenvalue.

$\lambda i = WSV_i / w_i$

$\lambda max = \lambda i + \ldots\ldots + \lambda_n / n$

Step 5: Finding the consistency and priorities- It is required to find consistency. We find the consistency ratio (CR). If CR<0.1, it is acceptable; otherwise, the re-evaluation of pairwise comparisons in the matrix is required.

The Consistency Ratio (CR) is obtained by Eq. (3)

CR=CI / RI

Where CI = Consistency Index,

RI = Random Index

The CI is calculated by Eq. (4)

CI = (λmax-n)/ (n-1)

Random index:

N	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

6.2 Results of AHP:

In the first step of AHP, the problem is designed in hierarchy form. At the top of the hierarchy, the decision goal is there. In this case, the decision goals are the Barriers most influential to the healthcare waste management sector. Different barriers are identified through literature review and expert opinion, and the most relevant ones are included: organizational, waste handling, human resource, and technical. These four categories of barriers are the hierarchy criteria, and the barriers under these categories are classified as sub-criteria shown in table 6.1

Table 6.1: Priority ranking of barriers:

	Barriers	OB	WHB	HRB	TB	Weight
OB	Organizational Barrier	1	3	5	6	0.52
WHB	Waste Handling Barrier	0.33	1	4	5	0.27
HRB	Human Resource Barrier	0.2	0.25	1	4	0.125

TB	Technical Barrier	0.16	0.2	0.25	1	0.05
CR= 0.07						

In the second step, the questionnaire was distributed among two hundred health professionals to collect their responses. Ninety-seven responses were received, resulting in a response rate of 48.5 percent and a reliability level of 95 percent, with a level of error of ±5 percent. Since the questionnaire was administered to a new set of respondents, location and field, the scale was going through exploratory factor analysis (EFA). The Kaiser–Meyer–Olkin value was 0.861, showing that the sample was adequate for factor analysis. The observed significance level for the Bartlett test of sphericity was 0.000. The relationship strength among the items was strong, which allowed to proceed with EFA. A principal component with equimax rotation was used. The rotated component matrix produced a fifteen-factor matrix with no cross loadings. The eigenvalue of all the factors was more significant. The total per cent of variance explained by the twelve factors was 83.822. The items were interpretable and could be grouped together as named based on past studies. The categorization of barriers is shown in table 6.2

Table 6.2: Categorization of Barriers

Barriers	Sub Barriers	Sub Barriers Coding
Organizational Barrier (OB)	Lack of coordination of hospitals with other authorities	OB1
	No priority to waste management issues	OB2
	No strict implementation of control measures	OB3

	No information regarding waste quantity and compositions	OB4
	No availability of recycling centers in Hospitals	OB5
	Lack of regular monitoring of healthcare waste	OB6
Waste Handling Barrier (WHB)	Lack of Govt. support and policies	WHB1
	No availability of segregation bins	WHB2
	No place for temporary storage and segregation	WHB3
Human Resource Barrier (HRB)	Lack of Qualification and awareness of employees	HRB1
	Lack of support from Management	HRB2
	People do not want to change their thinking	HRB 3
Technical Barrier (TB)	Poor training of staffs	TB 1
	Lack of intelligent waste management techniques	TB 2
	No tools and precautions to handle healthcare waste	TB 3

The next step used the responses to make pairwise matrices for the category and the barriers shown in table 6.3 to table 6.7. The pairwise comparison matrices show the weight of criteria and sub-criteria calculated through the experts' responses' geometric mean.

In table 6.1, the ranking of the category is given in which Organizational barrier is highly ranked with a weight of 0.52, followed by Waste handling (0.27), Human resource (0.125), and Technical (0.05). Within each category, the weights of barriers were calculated in the organizational barrier. Lack of coordination of hospitals with other authorities, with a weight of 0.32, is at the top, followed by No priority to waste management issues (0.28), No strict implementation of control measures (0.11), No information regarding waste quantity and compositions (0.09), No availability of recycling centers in hospitals (0.08) and at last Lack of regular monitoring of healthcare waste (0.07) which is shown in Table 6.3.

Table 6.3: Pairwise matrix and ranking of Organizational barriers:

	Barriers	OB1	OB2	OB3	OB4	OB5	OB6	Weight
OB1	Lack of coordination of hospitals with other authorities	1	2	4	4	3	2	0.32
OB2	No priority to waste management issues	0.5	1	5	5	4	2	0.28
OB3	No strict implementation of control measures	0.25	0.25	1	2	2	2	0.11
OB4	No information regarding waste quantity and compositions	0.25	0.2	0.5	1	2	2	0.09
OB5	No availability of recycling centers in Hospitals	0.33	0.16	0.5	0.5	1	2	0.08
OB6	Lack of regular monitoring of healthcare waste	0.5	0.25	0.5	0.5	0.5	1	0.07

CR= 0.04

In the case of the waste handling barrier, Lack of Govt. support and Policies is highly ranked with a weight of 0.66, followed by no segregation bins (0.22), No place for temporary storage, and segregation (0.10).

Table 6.4: Pairwise matrix and ranking of Waste Handling barriers:

	Barriers	WHB1	WHB2	WHB3	Weight
WHB1	Lack of Govt. support and policies	1	4	5	0.66
WHB2	No availability of segregation bins	0.25	1	3	0.22
WHB3	No place for temporary storage and segregation	0.2	0.33	1	0.10
CR= 0.017					

For the category of human resource barrier, Lack of qualification and awareness of employees (0.63), followed by Lack of support from Management (0.43), and at last, People want to keep their thinking the same (0.10). Whereas in the case of the technical barrier, the ranking of barriers is done in such a way that Poor training of staff (0.66), Lack of smart waste management techniques (0.22), and No tools and precautions to handle healthcare waste with weight (0.10).

Table 6.5: Pairwise matrix and ranking of Human Resource barriers:

	Barriers	HRB1	HRB2	HRB3	Weight
HRB1	Lack of Qualification and awareness of employees	1	2	5	0.63

HRB2	Lack of support from Management	0.5	1	5	0.43
HRB3	People do not want to change their thinking	0.2	0.2	1	0.10
CR= 0.008					

In the case of technical barriers, poor staff training is highly ranked with a weight of 0.66, followed by a Lack of smart waste management techniques (0.22) and, last, No tools and precautions to handle healthcare waste (0.10).

Table 6.6: Pairwise matrix and ranking of technical barriers:

	Barriers	TB1	TB2	TB3	Weight
TB1	Poor training of staffs	1	4	5	0.66
TB2	Lack of smart waste management techniques	0.25	1	3	0.22
TB3	No tools and precautions to handle healthcare waste	0.2	0.33	1	0.10
CR= 0.017					

In the final step, the global priority was obtained by multiplying local priority with the priority ranking for each category. The top barriers that are the most significant challenge for the healthcare waste management sectors are the Lack of government support and poor staff training, Lack of coordination of hospitals with other authorities, No priority to waste management issues, and Lack of qualification and awareness of employees.

Table 6.7: Overall Weight and Ranking of barriers

Categories	Priority of Category	Barriers	Local Priority	Global Priority	Overall Rank
Organizational	0.52	Lack of coordination of hospitals with other authorities	0.32	0.16	2
		No priority to waste management issues	0.28	0.14	3
		No strict implementation of control measures	0.11	0.05	5
		No information regarding waste quantity and compositions	0.09	0.04	6
		No availability of recycling centers in Hospitals	0.08	0.04	6
		Lack of regular monitoring of healthcare waste	0.07	0.03	7
Waste Handling	0.27	Lack of Govt. support and policies	0.66	0.17	1
		No availability of segregation bins	0.22	0.05	5
		No place for temporary storage and segregation	0.10	0.02	8
Human Resource	0.125	Lack of Qualification and awareness of employees	0.63	0.07	4
		Lack of support from Management	0.43	0.05	5
		People do not want to change	0.10	0.01	9

		their thinking			
Technical	0.05	Poor training of staffs	0.66	0.17	1
		Lack of smart waste management techniques	0.22	0.05	5
		No tools and precautions to handle healthcare waste	0.10	0.02	8

6.3 Strategies to overcome Barriers:

This study identifies various barriers and sub-barriers, which are the main obstacle to the proper implementation of healthcare waste management. To reduce these obstacles, Governments and Hospitals must take proper action. Therefore, this study identifies five strategies that are helpful in the elimination of the Barriers. These strategies are identified through expert opinion as well as Literature review.

Proposed strategies are described in Table 6.8

Table 6.8 Strategies to Overcome HCWM Barriers

Strategies	Description
P1: Increase Govt. Support and Policies	• Healthcare waste management sectors require support and policies to solve the issues related to this sector.
P2: Enhance the training and qualification of employees	• Good training of employees is essential because they know the consequences of healthcare waste and how to handle them by using handling tools. Proper treatment is Beneficial for the environment as well as for the human being.

P3: Increase awareness against consequences of healthcare waste	• Different types of seminars and workshops increase awareness among employees against waste. What are the new smart waste management techniques they will use for proper treatment? They will know by attending this type of seminars and workshop.
P4: Improve the coordination between hospitals and other authorities	• Coordination should be improved from top to bottom to make the process more convenient and supportive.
P5: Give priority to Healthcare waste management Issues	• Top Management has to be involved and prioritize issues related to healthcare waste. By prioritizing healthcare waste, the task related to this will be handled will more accurately and precisely. In this way, the chances of harmfulness through waste become weak.

6.4 Fuzzy TOPSIS Method:

Fuzzy TOPSIS's important step is determining the distance between fuzzy Positive and Negative Ideal Solutions (PIS & NIS) to each alternative. Fuzzy TOPSIS is a widely used MCDM approach. Therefore, a more suitable technique is to evaluate the weights and rankings of the criteria and alternatives employing linguistic variables with Triangular Fuzzy Numbers (TFNs), as shown in Table 6.9

The following steps are required for Fuzzy TOPSIS based on TFNs.

Step 1: Fuzzy Decision Matrix

Xij=(aij,bij,cij) where aij= min[aij^k], bij=1/k$\sum_1^k bij$, cij= max[cij^k]

k= Numbers of decision makers

Step 2: Normalized Fuzzy Decision Matrix

aj= min[aij] , rij=[aj/cij,aj/bij,aj/aij]

Step 3: Weighted Normalized Fuzzy Decision Matrix

Vij= rij*wj

Where wj= weights assign to the barriers

A1⊗A2= (a1*a2,b1*b2,c1*c2)

Step 4: Determine the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS).

A*=(V1*,V2*…Vn*) where Vj*=max[Vij]

A$^-$ = (V1$^-$,V2$^-$…Vn$^-$) where Vj$^-$=min[Vij]

Step 5: Find the distance between each alternative to PIS and NIS.

D(x,y)=sqrt1/3[(a1-a2)^2+(b1-b2)^2+(c1-c2)^2]

Step 6: Find the Coefficient of closeness (CCi) for each alternative to PIS and NIS solution

di*=$\sum_{j=1}^n d(Vij, Vj*)$

di$^-$=$\sum_{j=1}^n d(Vij, Vj-)$

Step 7: Prioritize and select the best strategy based on CCi value.

CCi= di$^-$/(di*+di$^-$)

Table 6.9 Linguistic Variables and TFNs

Code	Linguistic Variable	TFNs

1	Very Low	(1,1,3)
2	Low	(1,3,5)
3	Average	(3,5,7)
4	High	(5,7,9)
5	Very High	(7,9,9)

6.5 Results of Fuzzy TOPSIS:

Various strategies are identified to overcome the barriers. The fuzzy TOPSIS method is used to prioritize these strategies. With the help of experts, a fuzzy evaluation matrix has been formed using TFNs scales. The decision matrix, fuzzy normalized decision matrix, and weighted normalized fuzzy decision matrix were formed. The priorities ranking of the strategies has been obtained accordingly. Enhancing the training and qualification of employees is the best strategy for improvement in the healthcare waste management sector. Proposed strategies are shown in Figure 6.2, with ranking of strategy as shown in table 6.10

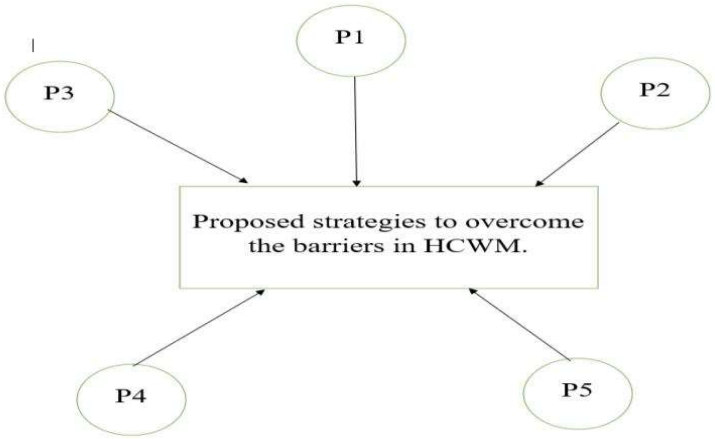

Fig 6.2 Proposed Strategies

Table 6.10: Ranking of Various Strategies

Code	Proposed Strategies	di^+	di^-	CCi	Rank
P1	Increase Govt. Support and Policies	8.73	4.72	0.35	III
P2	Enhance the training and qualification of employees	5.70	7.67	0.57	I
P3	Increase awareness against consequences of healthcare waste	9.37	3.87	0.292	V
P4	Improve the coordination between hospitals and other authorities	7.67	5.63	0.42	II
P5	Give priority to Healthcare waste management Issues	9.364	3.89	0.293	IV

6.6 Conclusion:

This study examines the barriers which are hindering in healthcare waste management sector. This study uses an extensive literature review with expert opinion and quantitative analysis of the Analytic Hierarchy Process (AHP) to find significant barriers and ranking. In the finding, Organizational barriers are the most crucial barrier, followed by waste handling and human resource and technical at third and fourth positions. These barriers have significant implications for society,

Strategy recommendations have been proposed with the help of fuzzy TOPSIS to adopt healthcare waste management procedures successfully. The appropriate measures must be taken to enhance the effectiveness and decrease the harmfulness of healthcare waste

management treatment. This study fills the research gap and assists policymakers in taking the most suitable solutions against barriers of healthcare waste (HCW).

6.7 Theoretical and Managerial Implications: This research suggests incorporating healthcare waste management strategies like increasing Govt. Support and Policies, Enhance the training and qualification of employees, increase awareness against consequences of healthcare waste, Improve the coordination between hospitals and other authorities and Give priority to Healthcare waste management Issues. Moreover, this research discussed the strategies that enable organizations to quickly recover from disruptions and guide them to attain a better position than competitors in the same environment.