# SELECTION OF MEDICAL WASTE TREATMENT CENTERS USING ANP

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## Abstract

The outbreak of the COVID-19 continues to date, which poses a great threat to social security and stability. In the short term, there is a large increase in the infectious medical waste (IMW), the pressure of medical waste treatment centers (MWTCs) is greatly enlarged and the probability of contact infection is significantly augmented. If IMW is improperly disposed of, it may accelerate the spread of the virus and pose a risk to the target population. Choosing the best disposal site for IMW is a challenging decision-making issue. Therefore, this paper proposes an evaluation model based on analysis network process (ANP), and establishes a universal risk assessment method system for MWTCs, aiming to determine the optimal treatment location of IMW, so as to effectively deal with a large amount of IMW in a very short time and reduce the risk of infection. Finally, the feasibility and effectiveness of the method are illustrated with an example of Wuhan, Hubei province, China during COVID-19. The conclusion of this study can provide a reference for the selection of MWTCs under infectious diseases.

Keywords: Waste treatment centers, Risk of infection, ANP

## 1 Introduction

The WHO (World Health Organization) has declared the outbreak of COVID-19 to be the sixth global public health emergency to date and a global crisis if left unchecked. Outbreaks usually lead to a sharp increase in infections within a short period of time, putting medical resources under extreme pressure. COVID-19 is highly infectious and has a wide range of the transmission route, so the daily protection must be taken. During the prevention, control and treatment of COVID-19, a large amount of IMW is generated, such as masks, disposable needles, nucleic acid testing waste, etc. A large amount of IMW is produced every day, which brings pressure to the MWTCs. Choosing a suitable medical waste treatment center (MWTC) can reduce the probability of infection risk.

Researches on the (IMW) have received a lot of attention. Liu et al. [1] researched the treatment of medical waste by using fuzzy multi-criterion decision making (MCDM) method. Jiang et al. [2] focuse on the best available technology system of medical waste centralized incineration facility and analyzes the application of technical transformation of medical waste centralized incineration facility. Aung et al. [3] established a model of hospital waste management evaluation criteria system using MCDM technology. Thakur and Ramesh [4] proposed a medical waste disposal enterprise optimization model based on grey theory, and applied the model to medical waste disposal enterprise optimization. However, the existing research rarely considers the selection of MWTCs. In addition, the decision-makers tend to ignore the mutual influence relationship among various indicators. The ANP takes into account the interactions between decision levels and is used well in many ways. Saaty [5]reviewed the application of analytic hierarchy process (AHP) and ANP in decision making

and summarized the differences between AHP/ANP and other decision making methods. Saaty [6]proposed some ideas and examples to apply ANP to the dynamic decision theory of time change. Razmi and Rafiei [7] built a submodel that contains ANP and is used to select suitable suppliers among existing suppliers. Tripathi et al. [8] proposed a framework of Service Measurement Index (SMI) based on ANP to sort cloud services. Ma and Wu [9] proposed a fuzzy ANP method based on linear objective programming model, which is used to determine the fuzzy global priority. Gupta et al. [10] came up with an combined method to select the best disaster retrieval solution using ANP and assessing optimal disaster recovery time using Multi-Attribute Utility Theory (MAUT).
This paper presents an evaluation model based on ANP, and establishes a universal risk evaluation method system for MWTCs. To minimize the risk, the ANP method was used to select and rank MWTCs. At the same time, typical hospitals in Wuhan, Hubei province, China under the COVID-19 epidemic were selected as an example to verify the feasibility of this method.

## 2 The method

### 2.1 The modeling ideas

AHP [11]and ANP [12] are both proposed by Saaty, and ANP is an extension of AHP. The ANP consists of a control layer and a network layer. The control layer mainly reflects the evaluation criterion of the goal realization and the network layer reveals the network structure, as is shown in Fig. 1.

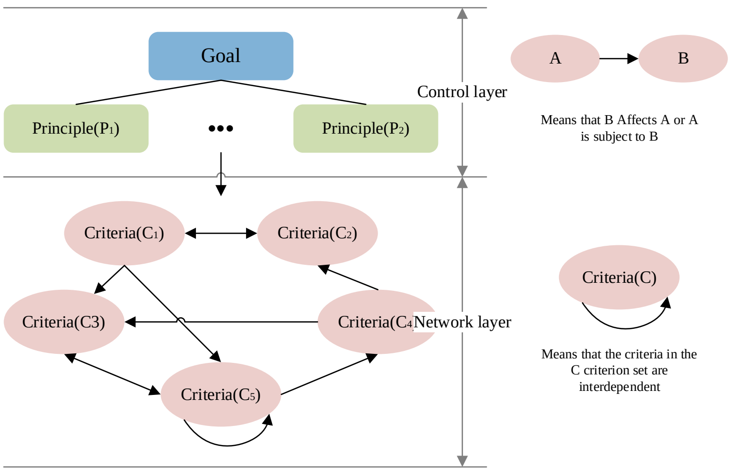


Fig. 1 The Typical structure of ANP

The establishment of ANP model includes the following steps:

(i) Establishing a hierarchical structure;
(ii) Constructing the judgment matrix;
(iii) Calculating the weight coefficient;
(iv) Establishing the unweighted supermatrix;
(v) Establishing the weighted supermatrix;
(vi) Establishing the limit supermatrix;
(vii) Sorting and choosing the final plan.

## 2.2 Constructing the evaluation criteria system

The establishment of the risk evaluation criteria system of the MWTCs needs to accurately reflect the probability of the risk occurring in the waste treatment process of the site, and its goal is to choose the best treatment site and minimize the risk of infection. The key factors reflecting the characteristics of the process were extracted and further discussed with experts in relevant fields to establish the evaluation criteria system, as is shown in Table 1.

Table 1. The detailed description of each criterion

| **Criteria** | **Sub-criteria** | **Explanation of criteria** |
|---|---|---|
| Experience and qualification ( $C_1$ ) | Technical level of operators ( $C_{11}$ ) | Operator's historical experience and technical capability |
| | Quality of treatment facilities ( $C_{12}$ ) | Treatment facilities correspond with standards |
| Equipment and technology ( $C_2$ ) | Configuration completeness of treatment facilities ( $C_{21}$ ) | Treatment facilities are capable of handling all types of medical waste |
| | Automation control level ( $C_{22}$ ) | Level of automation of equipment |
| | Disposal facilities operability ( $C_{23}$ ) | Handling facilities are easy to operate |
| Waste disposal site exposure to public ( $C_3$ ) | Area covered ( $C_{31}$ ) | The area specialized to a MWTC |
| | Instance from urban area ( $C_{32}$ ) | Distance of MWTCs from the urban |
| | Road conditions ( $C_{33}$ ) | Traffic flow, accident rate, etc |
| Release with health effects ( $C_4$ ) | Risk of producing poisonous and harmful pollutants ( $C_{41}$ ) | Produce poisonous and harmful pollutants risk |
| | Environmental impact risk ( $C_{42}$ ) | Pollutants release impact to ecological environment |
| | Personnel impact risk ( $C_{43}$ ) | Pollutants release impact to contact people |
| Probability of infection ( $C_5$ ) | Suitability of disposal facilities ( $C_{51}$ ) | Matching of treatment equipment to waste type |
| | Security protection measures deployment level ( $C_{52}$ ) | Whether the security measures are adequate |
| | Supervision means reliability ( $C_{53}$ ) | Whether the local supervision is strict |

The correlation table of each criterion is drawn based on expert opinions and the actual situation of medical waste treatment, as shown in Table 2.

Table 2. Sub-criterion association table

| | $C_{11}$ | $C_{12}$ | $C_{21}$ | $C_{22}$ | $C_{23}$ | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{41}$ | $C_{42}$ | $C_{43}$ | $C_{51}$ | $C_{52}$ | $C_{53}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_{11}$ | | | | | | | | | √ | √ | √ | | √ | |
| $C_{12}$ | | | | √ | √ | | | | √ | √ | √ | √ | √ | |
| $C_{21}$ | | √ | | √ | √ | | | | √ | √ | √ | √ | √ | |
| $C_{22}$ | | √ | √ | | √ | | | | √ | √ | √ | √ | √ | |
| $C_{23}$ | | √ | √ | √ | | | | | √ | √ | √ | √ | √ | |
| $C_{31}$ | | | | | | | | | √ | √ | √ | | √ | √ |
| $C_{32}$ | | | | | | | | √ | √ | √ | √ | | | |
| $C_{33}$ | | | | | | | | | √ | √ | √ | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_{41}$ | | | | | | | | | | √ | √ | | | |
| $C_{42}$ | | | | | | | | | √ | | √ | | | |
| $C_{43}$ | | | | | | | | | √ | √ | | | | |
| $C_{51}$ | | √ | √ | √ | √ | | | | √ | √ | √ | | √ | |
| $C_{52}$ | √ | √ | √ | √ | √ | | | | √ | √ | √ | √ | | |
| $C_{53}$ | √ | √ | √ | √ | √ | | | | √ | √ | √ | √ | √ | |

According to the correlation table between criteria and sub-criteria, the ANP network structure containing only the goal layer in the control layer is constructed, as shown in Fig. 2.

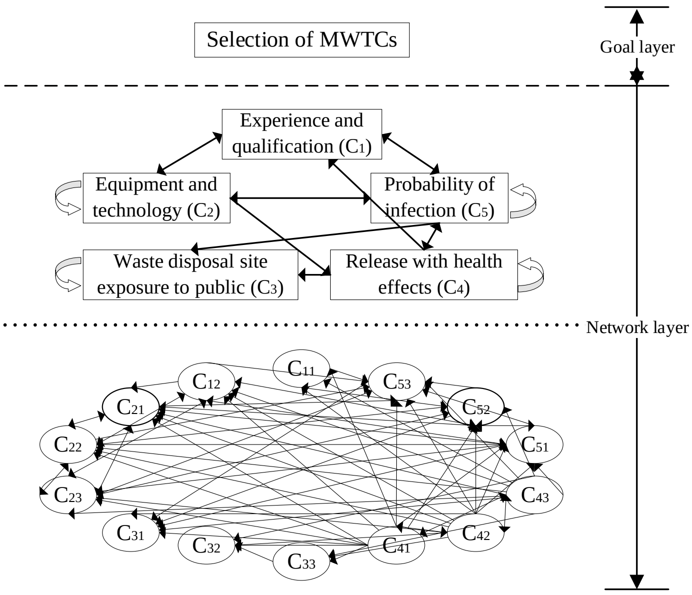


Fig. 2 The ANP network structure for selecting MWTCs

## 3 A case study in China

We selected three typical MWTCs in Wuhan, namely, Hanshi, Beihu Yunfeng and Qianzishan. According to the established evaluation criteria system, the final ANP structure diagram of MWTCs selection can be obtained, as shown in Fig. 3.

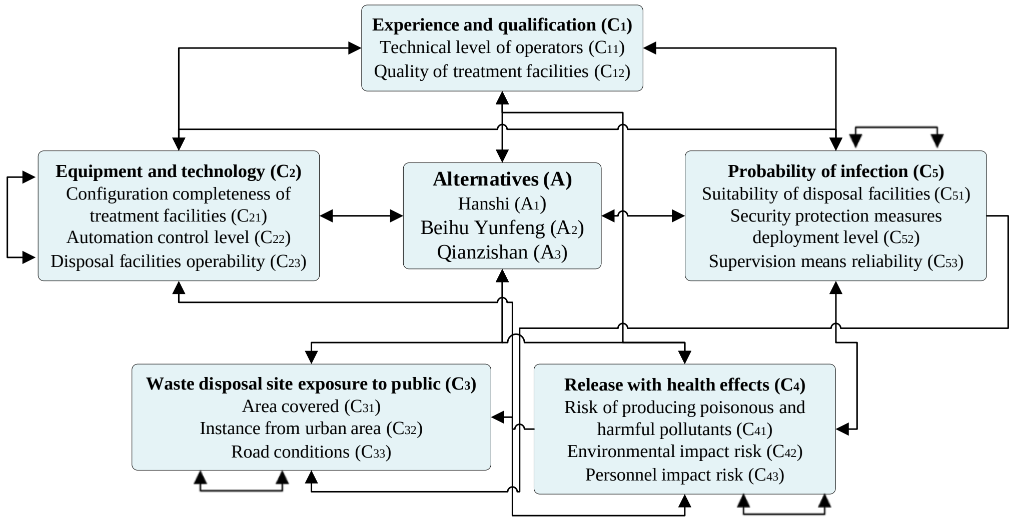


Fig. 3 The structure diagram of ANP method in MWTCs selection

One expert is invited to grade them. The Super Decision software was used to construct the network structure model for risk assessment of MWTCs, and the comprehensive evaluation value $V_k\,(k=1,2,3)$ of each treatment center was calculated. The end result is $V_1=0.364268, V_2=0.293579, V_3=0.342153$. Therefore, from the perspective of the least risk, we should choose Hanshi, followed by Qianzishan and Beihu Yunfeng.

## 4 Conclusions

In order to treat medical waste better, this paper presents a method of selecting MWTCs based on ANP. The indicators closely related to the risk of infection were selected to illustrate the effectiveness of the method by taking a typical MWTC in Wuhan as an example.

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