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Evaluation and Application of Aging-Appropriate Bathing Facilities Design Based on Grounded Theory and Fuzzy Analytic Hierarchy Process

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Abstract. Through field research on the home bathing scenes of assisted elderly people, grounded theory was used to code the original information of user interviews and bathing behaviors, and the various attribute needs of assisted elderly people for bathing behaviors were summarized. At the same time, the analysis was used as indicators in the analytic hierarchy process. The layer is being constructed; using this as the design index for aging-friendly bath products, experts are invited to evaluate and calculate the weight value of each index, and analyze the importance data of the indicators to design an aging-friendly bath product; finally, the fuzzy comprehensive evaluation method is used to test whether the plan is satisfactory. Degree, the study obtained the evaluation results of this program, proving the feasibility of combining grounded theory and fuzzy level analysis, making the theory and practice effectively connected and exerting practical significance. The combination of grounded theory and fuzzy level analysis can systematically carry out quantitative design and evaluation of products, reduce subjective influencing factors in the product design process, make the design more scientific, objective and rigorous, and provide effective program reference and optimization ideas for subsequent similar aging product design.

Keywords. bathing facilities, grounded theory, fuzzy analytic hierarchy process, Age-appropriate

1. Introduction

Actively responding to the aging of the population has been elevated to a national strategy. Bathroom space is a place where inconvenience and accidents are easy to occur in the daily life of the elderly, and the age-appropriate design and development of bathroom products is particularly important. The aging of the physical functions of the elderly makes it gradually difficult to take an independent bath, and various obstacles and safety hazards are prone to occur during the bathing process. Thomas M. Gill [1] et al. conducted experiments over a period of up to six years, showing that bathing has a higher probability of disability than other factors, suggesting the need for strategies to maintain and restore safe independent bathing in the elderly. William C. Mann [2] and

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other studies analyzed whether the elderly need auxiliary bathing equipment and what type of auxiliary equipment is needed, including bathroom non-slip mats, handrails, bath stools, bath chairs and bath transfer benches, while analyzing the problems encountered by the elderly when using bathing equipment, calling on people to pay attention to their own needs when choosing assistive equipment. At present, there are two forms of design of aging bath equipment on the market, one is an integrated integral product, which combines the design of multi-functional bath equipment; The second is a split combination product, by adding auxiliary facilities to the existing bathing environment, such as adding different types of armrests, installing bath folding chairs, replacing showers that are easy to adjust height, etc. For the split combined elderly bath products, the existing product types are relatively rich; The development of integrated and integral elderly bath products is still relatively single.

Song Duanshu [3] et al. studied the toilet and bathing behaviors and action postures of the self-care elderly, walker elderly and wheelchair elderly through observation, and finally used the age-appropriate and intelligent design strategy of bathroom products to guide the design practice, and designed a bath equipment that combines bathing and toileting. Xuan Wei [4] proposed the principle of barrier-free design of elderly bathroom facilities by analyzing the existing problems of elderly bathroom facilities in China and considering the actual changes in the psychology and physiology of the elderly. Hu Hong et al. [5] combined the FBS theoretical model and the user research method of service design to design the service strategy of online and offline elderly bath products, and output the design scheme of the elderly bath chair. Zhang Jian [6] In view of the lagging standard of some assistive devices in China, because the degree of attention of bath chairs is not as good as that of walkers, toilet chairs and other products, there is currently no domestic standard, research takes bath chairs as an example, actively promote the transformation of general requirements standards for assistive device products for the disabled, so that China's assistive device product standard system is more perfect.

Hu Shan [7] et al. summarized the influencing factors that lead to the difficulty of elderly using smart phones through rooted theory, and based on this, they sorted out the key design elements of the mobile phone guide APP for the elderly to carry out design positioning. Wang zhiyuan[8] et al. conducted a scientific and reasonable evaluation of children's scooter design through FAHP, which provided a quantifiable reference for the selection and optimization of children's product design scheme. Yang mei [9] et al. evaluate the weight values of each criterion of elderly smart watches more objectively and reasonably through the FAHP method, effectively avoiding errors caused by subjective judgment during evaluation.

This paper combines the grounded theory with the fuzzy comprehensive evaluation method, systematically organizes the interviews and user behavior demonstrations through the grounding theory in the early stage of design, summarizes the user needs in the age-appropriate bath design, and uses this as the basis to make the criterion layer and index layer elements in the analytic hierarchy method. Through the design practice of the weight value evaluation of the elements, the fuzzy comprehensive evaluation of the scheme is carried out, and the evaluation results are obtained. The combined application of the two methods systematically analyzes the content of the survey, and scientifically verifies it in the practical part.

2. Related theories

2.1 Grounded theory

In the overall context of American sociological research in the 20th century, American scholars Barney Glaser and Anselm Strauss published "The Discovery of Grounded Theory: Strategies for Qualitative Research", which first proposed the theory of rooting [10]. In Grounded Theory, researchers do not focus on testing hypotheses from existing theoretical frameworks, but develop a new "theory" based on empirical data collected in the field [11]. Grounded theory refers to the process of researchers obtaining field data in in-depth interviews, field observations and other practical methods, and gradually conceptualizing and theorizing them, which ensures the connection between theoretical analysis and empirical practice in the early stage. The process consists of three steps, namely open coding, selection coding and theoretical coding, and first the original data is screened by keywords and collected and classified; Next, the research is concentrated and sorted out and the scope analysis of related connections is carried out, and gradually focused, integrated and compressed. Finally, create the required theory.

2.2 Fuzzy Analytic Hierarchy Process

The fuzzy analytic hierarchy method FAHP combines analytic hierarchy and fuzzy evaluation method. The Analytic Hierarchy Process (AHP)[12] is a practical multi-criteria decision-making method proposed by Professor Thomas L. Saaty of the University of Pittsburgh in the early 70s of the 20th century, which represents a complex decision-making problem as an ordered hierarchical hierarchy and gives the order of alternatives through people's subjective judgment and scientific calculation. The analytic hierarchy method generally combines some other decision-making methods to flexibly deal with some more complex decision-making problems; If combined with the fuzzy evaluation method, first establish the indicators at each level through the analytic hierarchy method, output the fuzzy comprehensive evaluation results through the evaluation data, and combine the application to quantitatively analyze the perceptual evaluation and rationally output the evaluation results.

3. Age-appropriate bath product design rooted in theory

3.1 Research object

In the "Code for Building Design of Elderly Care Facilities" [13], the elderly can be divided into self-care elderly, intermediary elderly and nursing elderly according to their physical conditions. These three types of people have different needs in bathing behavior. The self-care elderly will basically not have difficulties in the bathing process, but it is necessary to pay attention to the prevention of falls in the elderly, because once the elderly fall down, it is difficult for the elderly to recover physically; assisting the elderly relies on crutches, handrails, wheelchairs and other lifting designs Or the elderly with assisted living equipment; nursing elderly refers to the disabled or semi-disabled elderly, who mostly use artificial assistance or bathtub assistance for bathing.

Through field research, it is known that the physical function of the self-care elderly is relatively good. On the whole, it is safer and easier for the self-care elderly to complete the bathing than to assist and care for the elderly. As for Jiezhu elderly, there will be more needs in bathing. Generally, various handrails will be installed in the bathing area, and sitz baths will be chosen when taking a bath. It is necessary to optimize the design of bathing equipment, and it is also the development direction and trend of the elderly market.

3.2 Research content

When using grounded theoretical methods, it is necessary to analyze and select users of original data should be representative [14], taking Xiamen as an example, during the period, 40 users were interviewed and 16 in-depth visits were made; Among them, 13 best users were selected to investigate and analyze the target users, family members and caregivers. Of these, 54% were women and 46% were men; Age distribution varies from 63 to 94 years; In the distribution of physical conditions, there are wheelchair users and crutches, among which crutches include walking inconvenience caused by pathology, slow movement caused by old age, and visual impairment that requires crutches assistance.

3.3 Open coding for age-appropriate bath product design

After the above investigation is completed, the original recording is sorted into text to extract the representative sentences, and at the same time, the original sentences are conceptualized and classified, and finally the corresponding main categories are analyzed and sorted out, as shown in Table 1.

Table 1. Rooted in theoretical coding builds

Extraction of raw statement information	conceptualization	Main category
This hand is unconscious, and bathing is generally bathing with one hand, including dressing	Physical impairments make bathing more difficult	physical factors
When washing your feet, raise your legs to your knees, support the wall with one hand, and rub with the other	Physical stability in old age is not good	
Before bathing, I need to adjust the water temperature, move the bath stool to the bathroom, and ask me to assist in bathing when I am not in good health;	The assistance required in case of changes in physical condition varies	
The caregiver comes to help me take a bath, and I will help him take a bath when he is not in good health	Need help bathing	
Exhaust fan switch in the bathroom, with a label.	Poor memory	
The chair is low, sometimes propped up directly from the floor	The height of the chair was uncomfortable, and the old man could not get up strongly	Human-machine dimensions
A new shower holder is installed because the original one is too high	Lower the height of the bath equipment	
Install a handrail, sometimes hold up to get things when bathing	The armrest supports getting up to pick up the item	Ancillary needs
Install handrails on the bathroom wall to help him walk in and out of the bathroom	Rely on support to avoid the risk of falls in and out of the bathroom	
Before bathing, you need me to help him adjust the water temperature	Need help to adjust the water temperature	
The eyes cannot see clearly, and generally distinguish shampoo and shower gel by the shape of the bottle	Distinguish items by shape	

It is not convenient to put chairs in the bathroom, the rest of the family members are not convenient to bathe	The chair is placed in the bathing area	environmental factors
The previous renovation did not take into account the current physical condition, and the renovation was troublesome	The original bathing environment is difficult to change	
When the hand touches the switch by mistake, the water temperature becomes cold or hot	False touch switch poses a risk	Security needs
The corner of the partition between the bath and the toilet is easy to collide.	Corners are easy to bump	
The bath chair installed on the wall should be perforated, and the metal parts will corrode over time	Pay attention to the stability of the chair	
The stainless steel chair I specially bought for her, it is relatively stable and can be used for a long time,	Worry about the life of the product	
Place the towel on the seat surface while bathing	Poor seat comfort	
The non-slip toilet floor has a height difference, and wheelchairs and bath chairs will be slightly inclined when entering the bathing area	Ground height differences affect operation and safety	
I sit while taking a bath	Sitz bath	Usage requirements
When adjusting the water temperature, first adjust to the hottest effluent, and then adjust to the coldest effluent	Water temperature visualization is not provided	
After bathing, put a dry towel on the chair to prevent getting wet when dressing	The seat is wet after bathing, and it is difficult to sit and dress	
Towels are not placed in public places, there will be a smell when I am old, and I will put them back in my room	Fear of family dislike	Psychological factors
He loves to be clean and divides towels a lot	Pay attention to personal hygiene	
I feel that there is no trouble, there is no need to install handrails, it is not good to install on the wall	Disobedience to old age	
Fill the basin with water at the right temperature and wipe the body with a towel	Security psychology	

In the process of sorting out interview data and bathing operations, 26 representative original information were selected, and the information was conceptualized and primary coded, and 7 main categories with internal logical relationships were integrated, namely physical factors, man-machine size, auxiliary needs, environmental needs, safety needs, use needs, and psychological needs. In order to ensure the reliability of the research results, the three original interview materials reserved were coded and analyzed again, and no new categories were generated, and the verification theory was saturated.

4. Evaluation of bath products suitable for the elderly based on FAHP

4.1 Construct a judgment matrix and calculate the weights of each indicator

By analyzing the seven factors of the main category, among which many safety hazards are gradually becoming difficult due to the decline of physical functions in the elderly, the physical factors and safety needs are summarized as safety indicators in the analytic hierarchy method; Many elderly people have the psychology of disobeying the old and afraid of their children's dislike, and the installation of bath products suitable for the elderly they often feel that it is the "label" of the elderly, so they are unwilling to accept it, so they must take care of the psychological burden of the elderly, so as to reduce the size of man-machine and psychological factors to comfort needs; With the development

of science and technology, it is relatively difficult for the elderly to operate the product, and the auxiliary facilities are the identification that distinguishes them from the young, thereby reducing the auxiliary needs and use needs to the ease of use indicators; Since the general family bathroom is a place shared by the family and is not easy to change, it is attributed to the inclusion index in the environmental factor; Some of these indicators are cross-subordinate. Finally, in the design evaluation index system of aging bath products, the criteria layer is divided into four elements: safety, inclusiveness and ease of use; There are 16 indicator layers under the benchmark layer, as shown in Table 2.

Table 2. Age-appropriate bath product design evaluation index system

Target layer	Corresponding encoding	Guidelines layer	Metrics layer
A Design evaluation index of aging bath products	2、8、9、15、16、17、19、21、26	B1 Security	B11 provides support facilities
			B12 Flat and non-slip ground
			B13 Shape is round and safe
			B14 The product structure is stable
			B15 Products have a long service life
	3、12、13、14、22、23、24	B2 Inclusiveness	B21 Has high versatility with family members
			B22 Device has a small footprint
			B23 The structure and technology need to match the original environment
			B24 High fault tolerance
	4、6、7、18、20、25	B3 comfort	B31 Added back flush function
			B32 The man-machine size is reasonable
			B33 Optimize the comfort needs of the sitz bath
			B34 Gentle and harmonious vision
	1、5、10、11	B4 ease of use	B41 Simple functionality
			B42 Convenient operation
			B43 The signs are eye-catching and easy to understand

In order to quantify the qualitative principle, the 1-9 proportional scale method compares between two elements, and evaluates the importance between the two elements of i and j, so as to form a numerical judgment matrix and calculate the weight value of each element. For the criterion layer B1, B2, B3 and B4, the importance of the two pairs was compared, and the weights between the elements of each criterion layer were determined. At the same time, the index layers B1, B12, B13, B21, B31, B41, and B42 are also compared with the importance of the size, and a certain value is assigned according to the importance, and the given value is marked as Dij(i.j=1, 2..., n), and i and j represent the evaluation elements of the pair-by-two comparison; Dij represents the important value of factors i and j relative to the target; n is the number of indicators, the constructed judgment matrix, ie

$$D = （D_{ij}）n \times n = \begin{cases} C11\ C12 \ldots C1n \\ C21\ C22 \ldots C2n \\ Cn1\ Cn2 \ldots Cnn \end{cases} \quad (1)$$

The evaluation matrix of elderly bath products was constructed, a questionnaire survey was conducted, and two university professors and two corporate executives were invited to form an evaluation team to form a decision-maker, and the obtained evaluation values were calculated by Yaahp software. The calculation results show that safety has the greatest impact on the design of age-appropriate bath products in the criterion layer,

with a weight value of (0.5872), followed by ease of use (0.2618), inclusiveness (0.0863), Comfort (0.0648); the importance of each indicator at the indicator layer is B14> B12>B11> B42> B41> B43> B13> B24>B32> B21>B15>B23> B33>B31> B21> B22> B34>B21, indicating that the four most important index elements in the design of bath products for the elderly are stable product structure, flat and non-slip ground, providing borrowing support, and convenient operation.

4.2 Age-appropriate bath product design practices

Design practices are developed through the importance data analysis of the above indicators, as shown in Figure 1. By optimizing the existing ordinary bath products, first, in the safety design, consider the safety control of temperature, round shape to reduce bumps, and add seats and auxiliary armrests; Second, in the design of ease of use, magnetic adsorption is used on the handrail for easy hanging and handling, and the function is simple; Third, in the inclusive design, consider the convenience of other family members, the bath chair is designed to be folded up and folded to reduce the obstruction to others, when the armrests on both sides are turned up and close to the wall, it is a magnetically attractive shower fixer; Fourth, in the consideration of comfort, reduce the height of the shower and gentle color vision.

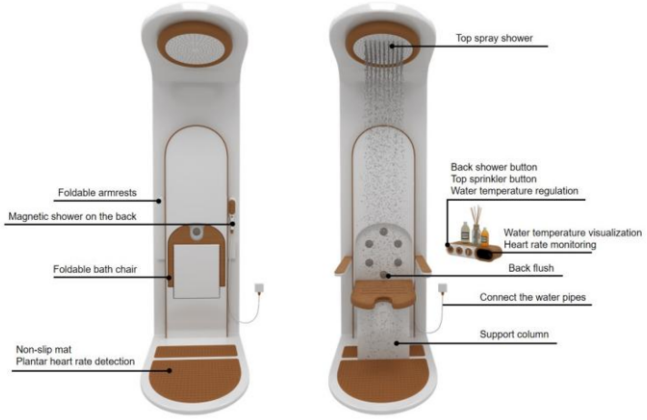

Figure 1. Rendering of age-appropriate bath products

4.3 Fuzzy comprehensive evaluation transformation matrix

According to the Likert scale survey questionnaire, the subjective feelings are transformed into quantifiable evaluations. Firstly, the design examples are set with five-point evaluation grades based on each index element, from very satisfied, satisfied, general, dissatisfied, and very dissatisfied. Scoring [15]. The experiment selected 20 consumers, ranging in age from 22 to 85, and collected 20 questionnaires, of which 19 were valid. The formula calculation is carried out through the questionnaire evaluation results and the weight values of each index, that is,

$$E = B \times R = \begin{cases} C11\ C12 \ldots C1n \\ C21\ C22 \ldots C2n \\ Cn1\ Cn2 \ldots Cnn \end{cases} \quad (2)$$

The results of the evaluation model are shown in Table 3.

Table 3. Evaluate the mode

Evaluation indicators R		5 Very satisfied with the proportion	4 Satisfaction percentage	3 Generally proportion	2 Dissatisfied proportion	1 Very dissatisfied with the proportion
B1	B11	0.3157	0.3684	0.3157	0	0
	B12	0.421	0.421	0.1578	0	0
	B13	0.3684	0.4736	0.1578	0	0
	B14	0.3684	0.3157	0.2631	0.0526	0
	B15	0.3157	0.2105	0.3157	0.1578	0
B2	B21	0.3157	0.3684	0.3157	0	0
	B22	0.421	0.2631	0.2105	0.1052	0
	B23	0.3684	0.421	0.2105	0	0
	B24	0.4736	0.421	0.1052	0	0
B3	B31	0.5263	0.3684	0.0526	0.0526	0
	B32	0.3157	0.4736	0.2105	0	0
	B33	0.3684	0.5263	0.1052	0	0
	B34	0.421	0.3684	0.2105	0	0
B4	B41	0.421	0.5263	0.0526	0	0
	B42	0.3157	0.5789	0.1052	0	0
	B43	0.5263	0.2631	0.5263	0	0

The weight values of each index calculated in the previous period are multiplied by the corresponding evaluation values, and finally the overall evaluation model is normalized to obtain E=(0.445, 0.459, 0.0715, 0.0232, 0), that is, the evaluation results of the designed scheme are: 44.5% are very satisfied with the scheme; 45.9% were satisfied with the programme; 7.1% felt that this program was average; A further 2.3 per cent were dissatisfied with the programme; At the same time, there is also 0% dissatisfaction. From this data, it can be seen that the overall evaluation of the program for aging bath products is level 5 very satisfactory and level 4 satisfactory, and the overall evaluation is good. Through data analysis, this solution satisfies consumers in terms of security and ease of use design; At the same time, it also shows that the installation of integrated bath products in the home bathroom environment has low adaptability, and consumers have concerns about integrated products; As for whether to add the back flushing function, different consumers will have different preferences. Finally, in terms of scheme optimization, strengthen the diversity of the back flushing function and provide the adjustability of the function; At the same time, the stability of the product is visually and structurally enhanced.

5. Conclusion

The "14th Five-Year Plan" National Planning for the Development of the Elderly Cause and the Elderly Service System proposes to strengthen the research and development and manufacturing of elderly products, focusing on the development of daily products such

as age-appropriate home appliances, furniture, bath products, toilets, and auxiliary products such as smart wheelchairs for different life scenarios [16]. Due to the great differences in physical functions, psychological states and behavioral habits of the elderly population, bath products must combine the key tasks and specific behaviors of target users to optimize the "user experience" and refine the "age-appropriate elements", but the initiative and accuracy of elderly users to express their own needs are not high, and the purchase behavior is not limited to the elderly themselves. Therefore, this paper proposes a design demand insight method for aging bath products based on grounded theory and fuzzy hierarchy analysis, and encodes the information obtained from in-depth interviews step by step through grounding theory, constructs theory, and reduces demand omission. Then, the output design indicators are transformed, and industry experts are invited to rank the weight degree of design indicators to ensure the objectivity and rigor of the index model, and finally identify the variables and conditions of user perceived value and user tendency behavior to further guide design optimization. Its operation process and evaluation method can provide a reference for similar product demand analysis and design innovation.

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