Upgrading Design of Medical Protective Clothing Based on User Experience

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Abstract—To design a more comfortable protective clothing for health care workers and those with a need for protective clothing. The current shortcomings of medical protective clothing are summarised through a basic approach to design research. The ROSTCM6 text analysis and the KANO model were used to analyse the key design factors and identify further design options. The ROSTCM6 text analysis and the KANO model analysis were two very effective tools in this investigation into the design of protective clothing.

Keywords-KANO; ROSTCM6; Medical Protective Clothing; User Experience

1 INTRODUCTION

During the COVID-19 epidemic, medical protective clothing for healthcare workers revealed many problems, such as poor moisture permeability, inappropriate size and difficulty in identification, resulting in a poor wearing experience for healthcare workers. In this paper, we propose to analyse the user experience and design a new type of protective clothing to improve the wearing experience of medical protective clothing.

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2 DESIGN RESEARCH

2.1 User Behaviour Analysis

The research team conducted in-depth research on the full set of donning and doffing processes and the behaviours involved in the process of wearing protective clothing for health care workers. The research material for the donning and doffing process was a video tutorial on donning and doffing protective clothing for healthcare workers published on the internet. The process was summarised in Figure 1. The main problems were the length of time it took to put on and take off, the lack of appropriate sizes and the large variety of protective equipment. The analysis revealed that the parts of the body that moved most frequently when wearing protective clothing were the wrists and ankles, and the parts that moved the most were the waist and elbows:

- Protective clothing is generally non-elastic and restricts the movement of healthcare workers.
- The poor breathability of protective clothing affects the comfort of healthcare workers.
- The design of protective clothing is not recognisable, which affects the efficiency of communication between healthcare professionals.
- The design of protective clothing lacks warmth, which can cause negative emotions in patients.

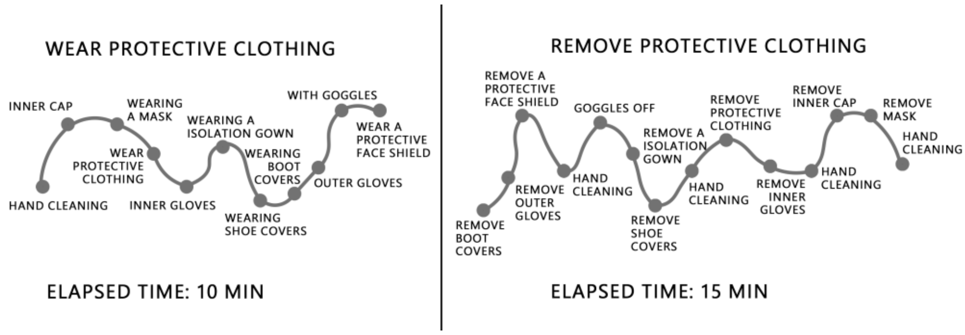

Figure 1. The Traditional Process of Wearing and Removing Protective Clothing

2.2 ROST-CM6 Text Analysis

ROST-CM6 text analysis software is a text analysis software developed by Dr. Shen Yang's team from Wuhan University, China, and is commonly used in humanities and social sciences research. The article mainly uses the Chinese word frequency analysis and sentiment analysis functions of the software [1].

(1) Word Frequency Analysis: The materials selected for this word frequency analysis were authoritative news reports from the official Chinese government media (mainly including People's Daily, China Central Television and other media). The key words retrieved were "medical protective clothing", "inadequate medical protective clothing", " medical protective

clothing discomfort", "protective clothing design". The frequency of words related to this study is shown in Figure 2.

Material Science	82	Size	28	Comfort	23
Design	52	Uncomfortable	28	Air Permeability	20
Security	36	Breathing	28	Quality	20
Research	35	Inconvenience	27	Laboratory	20
Faint	32	Human Body	27	Fabric	20
Medical Matters	30	Sweat	26	Physical Power	13
Research and Development	30	Physical Action	25	Size Not Fit	10

Figure 2. The Traditional Process of Wearing and Removing Protective Clothing

Words related to protective clothing material (e.g. material, breathable, fabric) accounted for 27% of the total word frequency: words related to protective clothing size (e.g. size, sizing, fit) accounted for 17% of the total word frequency: words related to protective clothing design (e.g. design, research, development) accounted for 14% of the total word frequency (the total word frequency is the sum of the word frequencies in the chart above). It can be seen that the material and size of protective clothing are the two most important concerns.

(2) Sentiment Analysis: The sentiment analysis function of ROST-CM6 software can quickly extract positive, neutral and negative words from the text material. positive, neutral and negative words of the text material, and further classify positive and negative words into average, moderate and high levels according to the intensity of the expressed emotion, while generating statistical files of positive, neutral and negative sentiment results to facilitate the investigator to understand the user's emotional attitude towards the product.

The research team used responses and discussions related to "protective clothing improvement" from mainstream Chinese social APPs such as Zhihu and Weibo as analysis materials, and the distribution of sentiments in each section is shown in Figure 3.

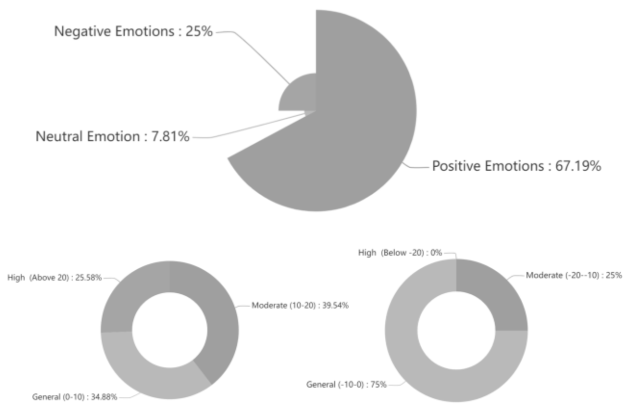

Figure 3. Emotional Distribution of Responses and Discussions on "Protective Clothing Improvement" on Chinese Social Media

Of these, 67.19% were positive, 7.81% were moderate and 25% were negative, which shows that overall the health care workers showed an optimistic attitude, but negative emotions still accounted for a significant portion. Of the negative emotions, 14.06% were general negative emotions, 4.69% were moderate negative emotions and 0% were high negative emotions. It is clear that although there is a shortage of protective clothing, it is not so extreme as to be unbearable. Further analysis revealed that the main focus of negative emotions was on the material and size of protective clothing, with key words that emerged were "soaking wet", "difficult to move when wearing", "easy to produce strangulation marks", etc. This is consistent with the results of the textual analysis of the news materials.

2.3 Research Conclusions

Based on the above research, the research team has summarised the following design flaws of protective clothing.

(1) The existing medical protective clothing is cumbersome to put on and take off. (2) The existing medical protective clothing is difficult to remove in a hygienic and quick manner. (3) The material of the existing medical protective clothing has difficulty in absorbing the large amount of sweat produced by the health care workers at work. (3) The material of the existing medical protective clothing is not able to absorb the large amount of sweat produced by the health care workers at work. (4) The cold appearance of existing medical protective clothing can easily give patients negative psychological implications. (5) The sizes of the existing protective clothing do not match the size of the health care workers and lack elasticity. (6) The existing medical protective clothing lacks identity recognition, which affects the efficiency of healthcare workers.

It is also possible to tentatively identify a few areas that have a greater impact on the user experience: the cumbersome process of putting on and taking off protective clothing, the lack of breathability of the protective clothing material and the lack of size matching the body shape.

3 NEW PROTECTIVE CLOTHING DESIGN PRINCIPLES

3.1 Functional Priority Setting

In response to the shortcomings of protective clothing as summarised in the research, the research team set initial functional points for the new protective clothing: (1) Protective clothing absorbs sweat and is not stuffy. (2) Protective clothing can be put on and taken off quickly. (3) The integrated design of the protective clothing. (4) The size of the protective clothing can be adjusted. (5) The emotional design of the protective clothing. (6) Protective clothing has a recognisable identity.

The following research team will use the KANO model analysis to prioritise the design of these function points. the KANO model is widely used in user satisfaction surveys and product improvement [2]. Desired demand means that user satisfaction increases as the product offers the feature and decreases as the product lacks the feature. Attractive requirements represent a significant increase in user satisfaction with the provision of the feature, but no decrease in user satisfaction without the feature. Non-differentiated requirements mean that user satisfaction is independent of the feature. Essential requirements mean that user satisfaction does not increase with the provision of the feature, but decreases significantly without it [3].

In the KANO model, the satisfaction coefficient after adding a feature is called the better coefficient (SI), and the dissatisfaction coefficient after eliminating a feature is called the worse coefficient (DSI). if the charismatic demand is A, the desired demand is O, the essential demand is M and the undifferentiated demand is I. then the better and worse coefficients are calculated as: SI=(A+O)/(A+O+M+I); DSI=-1*(O+M)/(A+O+M+I). The magnitude of SI and |DSI| is an important criterion for prioritising products. [4]

The research team distributed the Kano questionnaire on protective clothing wearing experience to healthcare workers who supported the large-scale COVID-19 outbreak in Wuhan, China in 2020 through both online and offline formats. 30 offline questionnaires were distributed and 28 valid questionnaires were returned. A total of 70 questionnaires were distributed online, with 60 valid questionnaires returned, making a total of 88 valid questionnaires completed. The better and worse coefficients were calculated for each design point. (As Shown in Table 1.)

Table 1 Better and Worse Coefficients Based on the KANO Model

Function Points	Better Coefficient SI	Absolute Value of Worse Coefficient |DSI|	Better Coefficient Average	Worse Coefficient Average of Absolute Values
Protective clothing that absorbs sweat well and is not stuffy	45.45%	27.27%	39.99%	21.26%
Protective clothing is easy and quick to wear & remove	33.33%	19.04%		
Integrated design of protective equipment	43.75%	25.00%		
Size adjustable protective clothing	60.00%	40.25%		

Emotional design of protective clothing in terms of colour and style	17.39%	0.02%		
Protective clothing with identity recognition	40.02%	16.00%		

It can be concluded that the size adjustment, integration of protective equipment and sweat absorption without stuffiness of protective clothing are aspirational needs, the identity recognition of protective clothing is charismatic needs, and the emotional design and quick-put-on/off design of protective clothing are undifferentiated needs. In product design, the following order should be followed: essential needs > desired needs > attractive needs > undifferentiated needs. Requirements of the same type should be ranked according to the sum of the absolute values of the better and worst factors. Design priorities: protective clothing is adjustable in size > protective clothing absorbs sweat and is not stuffy > protective clothing has an integrated design > protective clothing is recognisable > protective clothing is easy and quick to put on and take off > protective Emotional design with colour and style of clothing.

The top three design requirements are: size adjustment of protective clothing, integration of protective equipment, and protective clothing that absorbs sweat and is not stuffy. This is in line with the findings of the second part of the design study. As the research on protective clothing that absorbs sweat and does not suffocate heat is relatively complete, the new protective clothing design will not be discussed in this study and the size adjustment of protective clothing and the integration of protective equipment will be chosen as the focus of this new protective clothing design.

3.2 Safety Principles for Protective Clothing Design

As protective clothing is used in scenarios with high contamination and high virus density, attention must be paid to the safety of protective clothing when carrying out protective clothing design.

It has been shown that the safety properties of protective clothing are mainly focused on the structure and materials of protective clothing [5]. In particular, special attention should be paid to the airtightness of protective clothing in terms of the structure of protective clothing. Since the new coronavirus is mainly airborne and the eyes, mouth and nose are susceptible to infection, structural stitching should be kept to a minimum on the front chest. protective clothing should have openings on the back, shoulders and underarms as far as possible. In addition, protective clothing hoods should be combined with collars and cuffs and foot cuffs should be made of high stretch fabrics to enhance the protective clothing.

4 NEW PROTECTIVE CLOTHING DESIGN

(1) Integration of Protective Clothing: The biggest reason for the long time taken to put on and take off protective clothing is that it must be worn carefully to prevent contact between the virus and the skin and to prevent the virus from coming into contact with the face. If the airtightness of the head can be effectively ensured, healthcare workers will not have to worry about the threat of contaminants to the facial skin when taking off protective clothing, even if the hands and feet are not integrated, and the process of putting on and taking off protective clothing will be largely simplified. The research team therefore intends to enhance the airtightness of the face. In the initial solution, the main reason for the poor airtightness of the face was the gap between the goggles and the mask. The research team has improved this, the face was designed to be fully closed. A mask with high transparency and barrier properties is attached directly to the mouth of the cap, and a filter with the same filtration properties as the N95 mask is installed in the lower right corner of the mask to ensure that the health care worker breathes. The cuffs and leg cuffs, which have been removed from the integrated protection, are elasticated to ensure the airtightness and safety of the protective clothing and to facilitate movement and handling.

(2) Size Adjustment Modifications: the size adjustment has been designed to add an under garment allowance in addition to the size coverage. As shown in the figure, an elastic lace-up is added at the waist and abdomen. After wearing the protective garment, the length of the ties can be adjusted to control the amount of undergarment allowance.

The research team also identified specific sizing criteria for the new protective clothing, as shown in Table 2. (Unit: CM).

Table 2 Specific sizing criteria for new protective clothing

Size	Applicable Height	Height	Bust	Sleeve Length
S	155-166	160	120	70
M	166-178	175	130	80
L	178-190	190	140	90
Error	±2	±2	±2	±2

In order to increase the range of adjustability of protective clothing, the research team reduced the number of sizes and used only three sizes S/M/L. Each size also covers a larger range, with the size allowance between sizes being made up by Velcro. The Velcro is still located on the sleeves and the legs, with a plush fabric width of 8cm on the sleeves and an adjustable range of up to 9cm, and a plush fabric width of 13cm on the legs and an adjustable range of up to 14cm, which fully covers the set protective clothing size range. In addition, the hooked fabric band is 1cm wide, leaving a 1cm gap between the plush fabric band and the hooked fabric band to allow for the bending of the hooked fabric band. As the modified protective clothing will fit more snugly, pulling discomfort may be more pronounced in areas of constant movement such as the elbow, knee, waist and head and neck. The research team therefore replaced the original protective clothing material with an elastic protective clothing material for the elbows, knees, waist, head and neck. Considering that in practice, only transparent material is required within the eye range of the healthcare worker, the research team simplified the transparent face shield into a ring shape and adopted a half-wrapped head design to minimise the proportion of protective face shield material and to ensure the visibility of the healthcare worker.

5 CONCLUSION

This article has reviewed the shortcomings of current protective clothing and designed a new protective clothing product based on the user experience, which is adjustable in size and integrated with protective equipment. In addition, the ROST-CM6 text analysis and the KANO model used in the study can be widely used in other product design studies.

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