



Optimization of Proton Therapy Based on Service Design Theory

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Abstract. Proton therapy has been regarded the promising method for curing cancer. The proton therapy room plays an important role in the treatment procedure. With the rapidly spread of the proton therapy service, the treatment experience becomes a margin factor for improving treatment effect. In this paper, the service design theory was applied to guide the design of the proton therapy room. The prototype of proton therapy room was proposed. Based on our proposed design, the resource would be allocated more efficiently and the treatment experience would be improved in a large extent.

1 Introduction

Proton therapy [1] has been regarded as one of the most important methods for curing cancer in the future. Different to traditional radiation treatment by X-rays or gamma rays, the proton therapy utilizes the proton rays to cure the cancer by radiating at the diseased tissue. The protons energy radiation is first slow and then fast, which means the energy will not be released too much after the proton enters the body in a depth. Thus, when the position where the energy is released heavily matches the position of the diseased tissue, the diseased tissue can be killed without affecting normal cells. Proton therapy outperforms current ways of curing cancer and reaches an ideal level of treatment.

Thanks to the outstanding treatment performance of proton therapy, proton therapy center has been developing rapidly in the world. Until January 2016, over 45 proton therapy centers have been established. Most of them located in USA, Europe and Japan. Over 96537 patients have received proton therapy. However, the proton therapy is currently a new thing in China. With the developing of treatment methods and the living standard of people, proton therapy will gradually gain a more rapid speed of developing.

Nowadays, the main focus of proton therapy is improving the success rate of treatment. The demand is higher than the hospital resources. In this circumstances, patients may not be sensitive to the experience when getting treatment. However, as more and more hospitals are able to provide proton therapy, the treatment experience will become a major factor affecting the patients selection

for the hospital. Whats more, with the development of technology, the basic success rate of treatment is relatively high. The treatment experience will become an essential margin factor affecting the effect of the treatment. Also, proton therapy is a complex treatment method comprising many processes and resources integration. The optimization of resources utilization is beneficial to improving the treatment effect. From these points of view, the design for a more friendly and reasonable proton therapy has been an meaningful topic.

Proton therapy has complex procedures of treatment. The proton therapy room plays an important role during all the procedures since cancer cells of patients will get irradiated by the proton rays in this room. In this paper, the service design theory [2–4] is applied to offer the patient a more reasonable and pleasant treatment experience in the proton therapy room. As far as we know, few study has studied this field. There are mainly three contributions of our work: 1. Service touchpoints of proton therapy were extracted based on theoretical analysis; 2. Insights from the questionnaires survey and field survey were obtained to find the demand of patients; 3. A prototype design based on service design theory was provided to optimize the treatment experience of proton therapy.

2 Service Design Analysis of the Proton Therapy Treatment Room

The particular treatment process from different proton therapy centers may be different from each other. The optimization conducted on a specific type of treatment process is not general enough. The aim of our work is to provide the optimization for the overall service in the proton therapy treatment room based on service design theory. So the abstraction of the process in the proton therapy room is conducted and a process model of treatment is established. Based on the obtained process model, touchpoints of the proton therapy service are extracted from the view of service design.

2.1 Process Model of Proton Therapy Treatment Room

By comparing the proton therapy in the treatment room of different centers, the process model of proton therapy treatment room is established in Fig. 1. The process model is composed of five parts: 1. Before the treatment, the patient need to make some preparations. Particular preparations include changing clothes or getting medical instructions. 2. The patient enter the treatment room, put on their specially design mold and get fixed in the specific gesture and position with the help of the doctor. 3. The machine starts to work. CT is taken on the patient to locate the targeted diseased tissue. And the machine rotates to find the angle for radiating the proton rays. 4. The proton rays are radiated on the tissue. 5. Treatment is over and the patient leaves the treatment room. The whole treatment process last around 30 to 40 min, regarding the specific disease. The process model provides the basic material for the service design of the proton therapy treatment room.

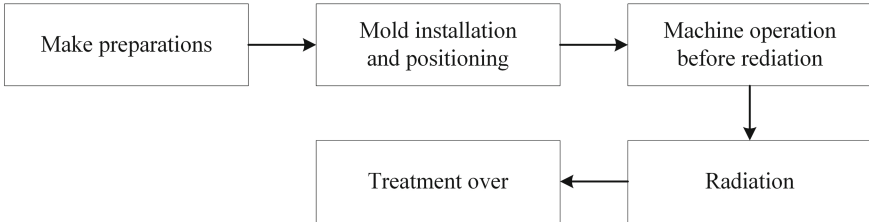


Fig. 1. Process model of proton therapy treatment room

2.2 Service Touchpoint Extraction of Proton Therapy

The process model is the generally an indication of the patient experience. The service touchpoints could be extracted from the process model. Based on the service design theory, service touchpoints interact with the patient through senses. Combining the process model and five senses, the service blueprint of the proton therapy treatment room is proposed and service touchpoints are extracted based on the service blueprint. The service blueprint of proton therapy is shown in Fig. 2.

Patient	Change clothes	Enter the treatment room	Be positioned and fixed	Be scanned	Be radiated	Leave the treatment room		
Doctors	Help with the patient		Give medical instructions	Observe or give instructions	Observe or give instructions	Help with the patient		Patients behavior
Treatment bed			Support the patient	Support the patient	Support the patient			
Treatment machine				Target zone confirmation	Cure the cancer			Frontstage service
Treatment room space		Provide atmosphere	Provide space for treatment					
Maintaining team						Maintain		Backstage service

Fig. 2. Service blueprint of proton therapy treatment room

Five service touchpoints are extracted from the service blueprint, including treatment room space, treatment bed, treatment machine and doctors. Treatment room space is the visual image of the patient. The space elements include the light, layout and decorations. The space could have effect on patients psychology through space elements. Treatment bed is the main service touchpoint when the patient getting treatment. The patient has to contact the with treatment bed through the whole process. Treatment machine radiates the proton rays to the patients body. Doctors help the patient fix the body and get on the treatment bed, give medical instructions when the treatment goes on and supervise the treatment procedure. The optimization of the proton therapy service is mainly conducted on the service model through service touchpoints.

3 Insights of the Proton Therapy Service

Optimization of service touchpoints should base on the insights of the service touchpoint. In order to get insights of the service touchpoint, three ways of research have been conducted, including public information collection, questionnaire survey and deep interview. Public information collection is the basis for questionnaire survey. The questions of questionnaire is extracted the public information collection. Questionnaire survey focuses on some general problems of the patient. Deep interview is conducted with both patients and the stuff in the hospital in order to dig more valuable information.

3.1 Public Information Collection

In order to design a reasonable questionnaire, the question should be carefully designed. Since the aim of the work is optimize the service touchpoint, the potential part for optimization should be found. In this section, the public information collection is conducted to find the potential part for service touchpoint optimization. Several images of the service touchpoint were found to illustrate the potential part.

In Fig. 3, the proton therapy treatment space is shown. From Fig. 3, it can found that the proton therapy treatment space service touchpoint mainly contains three part, the light, the layout and the decorations. The luminance and color of light may have effect the overall atmosphere of the proton therapy treatment room. The layout of the room represents the position of different function zone of the treatment. And the decoration mean the additional furniture not directly related the treatment. Some potential problems were also shown in Fig. The color of light may be cold, combining with the cold machine and technology, the feeling of color may be not warm enough. The space seems empty and lacks of positive visual elements.

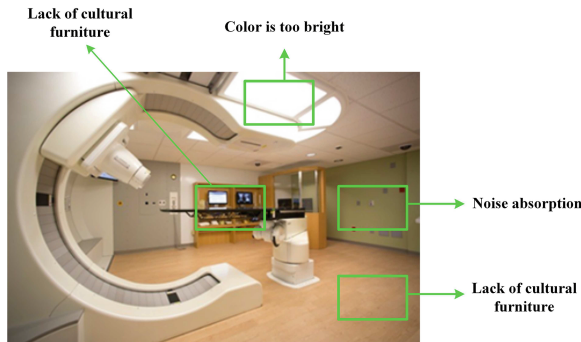


Fig. 3. Proton therapy treatment space

In Fig. 4, the treatment machine is shown. When operating, the machine brings some noise which causes tension feeling of the patient. The rotation of the machine may causes some feeling of dizzy. The distance between the treatment bed and the alarm light may be too close. The flash of the light causes tension feeling of the patient.

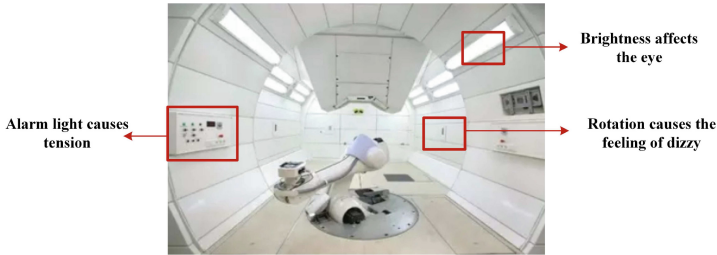


Fig. 4. Treatment machine

The treatment bed service touchpoint is shown in Fig. 5. Several potential problems in Fig. 5 exist. The patient may feel cold since the treatment rooms temperature is relatively low in order to maintain the operation of the machine. The height of the treatment room may cause the patient feel unsafe. The patient is not protected from falling of the treatment bed. In addition, the channel for calling doctors for help is missed from the picture.

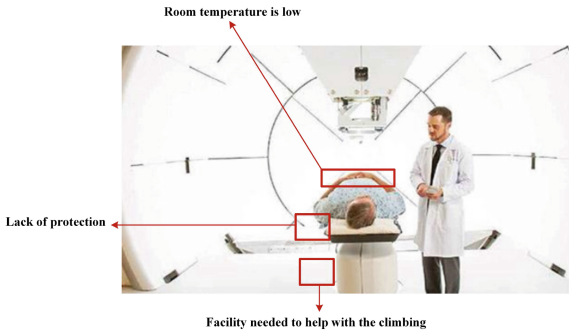


Fig. 5. Treatment bed

3.2 Questionnaire Survey

Proton therapy and the traditional radiation therapy utilize similar ways of treatment method which is radiating particles into the human body. The similar mechanism causes the similar arrangement of the treatment room and similar outlook of the treatment machine. Similar treatment room and treatment

machine lead to similar experience of the patient. Since the proton therapy center has not been widely used, the questionnaire survey is conducted among the patient who have received traditional radiation therapy. 200 questionnaires have been distributed and 152 were retrieved. The analysis was conducted on the retrieved questionnaire.

The questionnaire is designed based on the service touchpoint of the service model, as shown in Table 1. For each touchpoint, several related questions were surveyed. The questions were extracted from but not directly borrowed from the public information collection. For the treatment space, the color and luminance of light were surveyed. The high level of light intensity may bring the patients pressure. Cold series of color strengths the sense of technology, leading the feeling of distanced. Alarm light is necessary for operation of the therapy, but the visibility by patients may bring additional pressure. For treatment bed, the convenience for climbing, the feeling of temperature and the height of position are surveyed. For the doctor, the privacy protection and the effect of communication are surveyed. And for the treatment machine, the noise of the machine, the procedure notation and the luminance of light are surveyed. The questionnaire is designed using the Likert scale, with the score of each question from 1 to 5. The result of the questionnaire is shown in Table 1. For the treatment room space, the average score of light intensity is 3.3, which indicates that the intensity is normal. But the average score of light color is 3.8, representing that the color is too light. The alarm clock also affects patients feeling. So the treatment room space needs optimization on the light color and alarm light. For the treatment bed, the temperature seems a little bit cold for the patient. This phenomenon is caused by the material of the treatment bed. Also, the feeling of height when

Table 1. Questionnaire about the service touchpoint

Service touchpoints	Questions	Score from 5 to 1	Average score
Space of treatment room	Luminance of light	Too high→Too low	3.3
	Color of light	Too bright→Too dark	3.8
	Effect of alarm light	Much affected→No affected	3.9
Treatment bed	Convenient to climb	Easy→Hard	4.1
	Feeling when contacted	Cold→Warm	3.5
	Feeling of height	Too high→Too low	3.8
Doctor	Respect of privacy	Excellent→Terrible	4.2
	Communication	Effective→No effect	2.9
Treatment machine	Noise of machine	Too loud→Too low	4.0
	Familiarity of machine procedure	Well familiar→Lack of knowledge	2.1
	Luminance of light	Too high→Too low	3.5

the patient lying on the treatment bed is obvious, with the average score of 3.8. For the doctor, the communication with the patient scores low. The communication between the patient and the doctor when the patient lies on the bed may contain instructions and the current progress of treatment. For the treatment machine, the noise is relatively loud and the patient is not familiar with the current operation progress of the machine. And the light of the machine is normal.

3.3 Deep Interview

The public information collection and the questionnaire survey mainly deals with some general problems. In this section, three representatives of the proton therapy service were deeply interviewed in order to get a deep understanding of the current service. 2 oncologists, 3 radiation doctors and 5 patients were interviewed about the experience of the radiation therapy service. Based on the material collected from the interview, the character profile is established in Table 2.

From Table 2, it can be concluded that the optimization on the service model is also necessary. Some demands can not be satisfied only by the service touch-point optimization. The optimization should be extended to the process of the proton therapy.

Table 2. Character profile of the staff

Name	Li Wei
Occupation	Oncologist
Demand statement: The treatment procedure is complex and time consuming. Some patients do not understand my work and treatment plan. Thus some misunderstandings are created. The way to inform patients are difficult. Sometimes the patient is difficult to reach	
Name	Zhao Shi
Occupation	Radiation doctor
Demand statement: I have to go from room to room to conduct different tasks. This is time consuming and makes people feel tired. Different people have different target zone, thus making the fixing procedure cost too much time. Although the instruction have been told to the patient, some patients still act the wrong way	
Name	Zhou wu
Occupation	Patient
Demand statement: When lying on the treatment bed, I do not know current status of the machine. Since there is no one in the treatment room when the radiation happens, I feel helpless and worried. When getting treatment, I have to stay static, which is very tired since the process lasts long	

4 Service Design of Proton Therapy

The abstraction of the proton therapy service is conducted and the service model is obtained. Combining with insights obtained from the public information collection, questionnaire survey and deep interview, the new service of proton therapy service is proposed. There are mainly three aspects of innovations: static service touchpoint optimization, new service touchpoint optimization and process optimization.

4.1 Static Service Touchpoint Optimization

Based on the insight obtained from previous mentioned survey, the service touchpoint optimization is conducted. Current static touchpoint mainly contains treatment room space, treatment bed, treatment machine and doctors. Treatment room space affects patients psychology. The optimization should focus on ease psychology tension and pressure. The aspects of treatment room space optimization include light, layout and decorations. Treatment bed interacts with the patient through touching. The patient lying on the bed and the treatment bed acts as the role of supporting and fixing. Thus, the optimization of treatment bed should focus on safety, comfort and stability. The treatment machine optimization should be based on not reducing the treatment effect. On the premise of this, the psychology pressure should be reduced. The doctor provides more instructions and communicates better with the patient.

The space of the room creates the atmosphere of treatment. The atmosphere affects the patients psychology. The aim of treatment room optimization is to create positive feeling for the patient. The light in the room contain primary light, light for the machine to position the target zone and the assisting light. The primary light usually locates on the ceiling of the room. In traditional service model, the potential of primary light has not been fully exploited. In the proposed service model, the adaptive light system is applied. The color and the intensity of the light system is able to modify to meet the demand of different patients. The optimization of light system can provide different atmosphere to fit different psychology status of the patient. The illustration of the light system is shown in Fig. 6.



Fig. 6. Light system prototype

For the layout of the treatment room, the structure can also be optimized. The overall layout can be classified into three different zones including treatment zone, observation zone and patient zone. The design of these zones is that the patient zone and the observation zone connect to the treatment zone through different entrances, but the patient zone and the observation zone are separated. In addition, the observation zone should be hided from the public contact. From our insights, doctors suffer from heavy body work from going from room to room, the separation of patient room and separation room reduces the distance that doctors have to cover. Also, the privacy of the patient could also be protected if the doctor get in the treatment room through a different door. Since the doctor can observe some privacy of the patient in the observation room, the observation should be protected from public contact. In conclusion, the proposed layout satisfies the demand of patients and doctors. The service touchpoints are optimized and the efficiency of the operation improves. The proposed layout principle is presented in Fig. 7. For the decoration, the principle is to create the positive indication of feeling. Specifically, the wall of the treatment room should be placed with pictures and paintings. The picture and the painting should contain positive images and the treatment room should be placed with some green plant. The aim of decoration is to create the atmosphere of warmth and health.

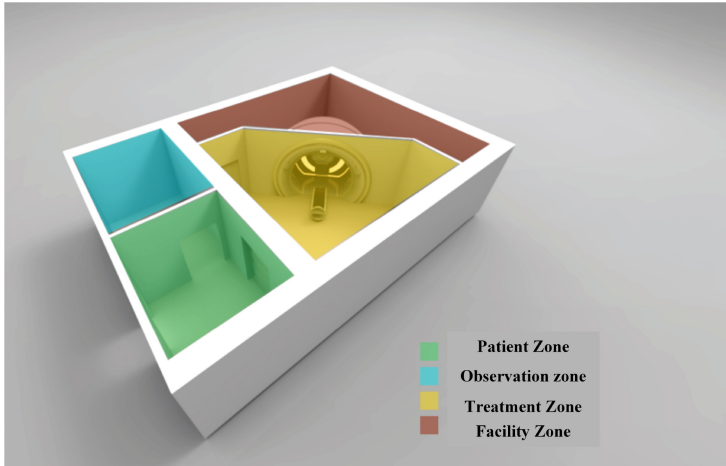


Fig. 7. Layout of the treatment room

The principle of designing the treatment bed should consider comfort, safety and stability. The main design relating to the comfort is that the treatment beds material should be carefully selected to protect the patients body temperature. And the treatment bed should be equipped with a automatic height changing facility to release the feeling of height. The safety design part is that the structure

of the treatment bed should be designed as a semi surrounded one. This structure can protect the patient from falling from the bed and provide the patient with a feeling being protected. In addition, an emergency call button should be provided to the patient to call for the doctor. Whats more, the treatment bed could be designed as a mobile bed. This design can realize the customized treatment bed and prevent from cross infection. The stability part design is that the treatment bed should implements a smart control system. The control system can adjust the position of the bed more precisely compared to the artificial way. The prototype of the treatment bed in shown in Fig. 8.

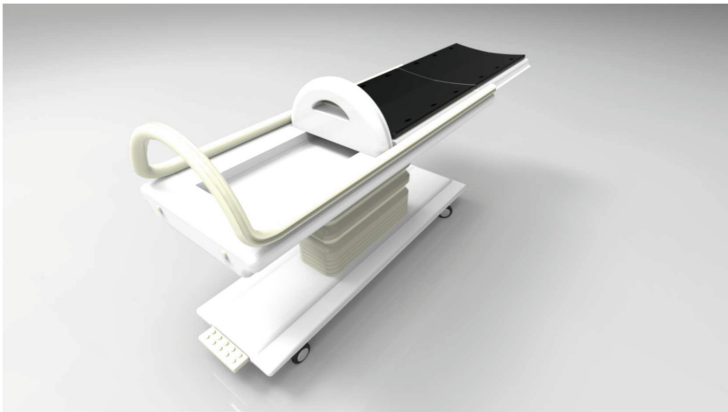


Fig. 8. Treatment bed prototype

The treatment machine surrounds the patient when the patient get treatment, thus creating an enclosure space. The principle of the treatment machine design is to reduce the pressure to the patient. The light inside the machine should be designed as relatively low. The rotation of the machine can cause the patient feel dizzy thus some protection method should be implemented. The machine should report the current status of the operation to inform the patient in order to release the pressure. In addition, the alarm light should be placed in some place invisible by the patient. The prototype of treatment machine is shown in Fig. 9.

The doctor should perform duties of instructing and conciliating the patients. The optimization contains in the aspects of informing every stage of treatment, explaining the phenomenon of current operation and answering questions of the patient. The communication between the doctor and the patient should not be negative way which the patient starts but the positive way, which is controlled by the doctor.

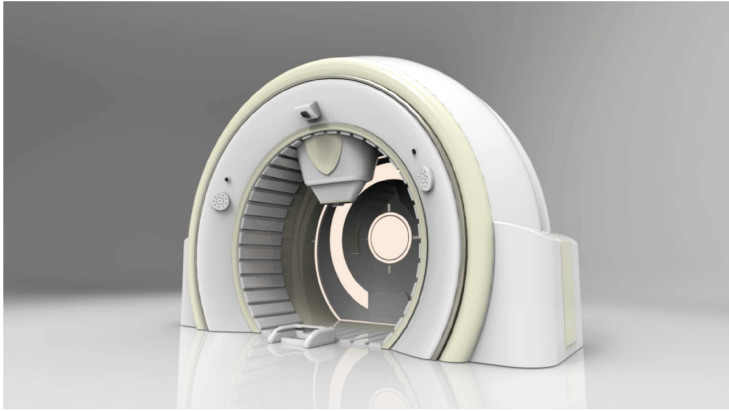


Fig. 9. Treatment machine prototype

4.2 New Service Touchpoint Application

New service touchpoint application is necessary to optimize the treatment experience and improve the treatment effect. Two potential additional service touchpoints are proposed to enhance the service model.

VR/AR system could be used in the proton therapy treatment. The system could be used in multiple ways to improve the efficiency of the treatment. First, the system could be used in the rehearsal phase of the treatment providing guidance in a vivid way. In addition, the VR device could be used when the patient is getting treatment. The dizzy feeling caused by rotation can be reduced.

Media playing system could be added in the treatment room to provide enhancement of service touchpoint through the hearing sense. The customized list of song could be played when the patient lying on the treatment bed. In this way the pressure could be reduced.

4.3 Process Optimization

Traditional service blueprint includes changing clothes, getting customized mold, entering the treatment room, fixing the position, getting treatment and ending. The traditional service blueprint has several disadvantages. First, the mold installation and position fixing take a long time for the doctor to cooperate. Also, the patient has to wait for a relatively long time to get treatment after last patients treatment is over. In addition, the doctor has to get into the room several times to operate and stays in the room for a long time. Thus the accumulated received radiation is large and impairs the doctors health. In conclusion, the doctor suffers from much frequent room entrance and long time staying, when the patient suffers from long time waiting.

We propose to moves the mold installation procedure from after entering the treatment room to before entering the room. This change is based on the layout

optimization and the treatment bed optimization. One patient is installing the mold and get fixed on the movable treatment bed with the help of the doctor while the other patient is getting treatment in the treatment zone. When the other patient finishes the treatment, the patient in the patient zone can enter the treatment room. This mechanism saves the time for doctors staying in the treatment room. In addition, the doctor can be separated into two groups, with one group in the patient zone helping the mold installation and position fixing, the other group in the observation zone. The proposed process improves the operation efficiency and protects the doctors health.

5 Conclusion

The optimization of proton therapy treatment room was conducted on this paper. Based on the service design theory, the service touchpoint was extracted through viewing the proton therapy room as a service. In this way, the principle for designing the proton therapy treatment room was proposed. And the prototype of the treatment bed, treatment room and treatment machine was realized. Future direction could contain the design of the proton therapy hospital.

References

1. Smith, A.R.: Proton therapy. *Phys. Med. Biol.* **51**(13), R491–504 (2006)
2. Stickdorn, M., Schneider, J.: This is service design thinking: basics, tools, cases. Loan/open Shelves (2011)
3. Zomerdijk, L.G., Voss, C.A.: Service design for experience-centric services. *J. Serv. Res.* **13**(1), 67–82 (2010)
4. Patricio, L., Fisk, R.P., Cunha, J.F.E., Constantine, L.: Multilevel service design: from customer value constellation to service experience blueprint. *J. Serv. Res.* **14**(2), 180–200 (2011)