Exploring Medical Context Information during Radiation Therapy by Visualization System Applied for Medical Personnel

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Abstract

During long term treatment, contextual information of patient is often misunderstanding and a very difficult task for medical personnel to collect in order to provide appropriate suggestion, visualization and comparison of multiple patients or status can provide insights just in time. This research will design a Medical-Patient Interactive System for clinical use, by patients undergoing radiotherapy and radiologists and doctors who perform treatment. Then through the using of this interactive system and various records, the clinical process of treatment the patient's response is recorded and analyzed as visual data. Medical personnel can help patients through these dialogues and records the treatment, which is completed stably, and a database can be built for patients to undergoing radiotherapy, and it can also provide valuable patient's response data for medical personnel in the radiotherapy department. In the future, the related research with different types of cancers on possible conditions during the treatment process, besides the patient's response at each stage of the treatment course can be a reliable basis for medical personnel to face patients.

Keywords: Medical-Patient, Information Visualization, Medical-Patient Interactive System, Radiation Therapy Department, D3.js

1. INTRODUCTION

1.1 Background Motivation

During long term treatment, contextual information of patient is often misunderstanding and a very difficult task for medical personnel to collect in order to provide appropriate suggestion, visualization and comparison of multiple patients or status can provide insights just in time.

The duration of radiation therapy varies according to the condition. The short course is four to six times, and the long course is several weeks to several months. Regardless of the first course of treatment, some patients will feel a little uneasy or fearful before and after each treatment. Especially the patients who received radiation therapy for the first time, the anxiety is the most obvious (Lewis et al. 2015); during the treatment, the patient's mood and psychology will be unstable and helpless, and there will also be fear and anxiety. Depression may be associated with lower survival rates (Watson et al. 1999). And most of the cases with better outcomes are also faced with a positive attitude during the course of treatment, including the interaction and trust between medical personnel and patients.

There are many relevant literatures and cases now to help medical personnel and patients communicate effectively. For example, in the study of Dyer (2018), virtual reality was used to train students in the medical system. It is difficult to actually contact patients during the educational process, and when they can contact patients, they have already left the education system. Therefore, this system can help students who are studying to realize that patients are in the course of treatment. From the perspective of establishing a correct attitude towards medical treatment. There is also auxiliary software for medical-patient communication, which is used to allow medical personnel and patients to share information and communication, the feature of this system is anonymous communication. In this way, patients can communicate with medical personnel without any burden and reservation (Sonwane et al. 2017). However, this method needs to be combined with remote monitoring technology to send the patient's physical information into the database of the monitoring center, and then transfer the data from the APP for diagnosis and treatment and discussion. Liu (2016) established a remote transmission system to intelligently, the method locates and tracks the physiological information of the patient, analyzes, and organizes the results into a medical record file and stores it in the monitoring center for remote diagnosis and monitoring.

To sum up, from the change of medical-patient relationship and emotional connection to the digital carrier added value of medical-patient communication, it can be observed that the intervention of these digital products which is based on the physical health of the user. Quarantine and quick understanding of the patient's medical history and information can indeed help the patient's psychological needs; and for the patients with radiation therapy, long-term treatment or medication, the subject of this study, psychological support can also improve on-time. Therefore, this study is based on the position of medical personnel and constructs an APP with reference value for disease and a system that can visualize information.

1.2 Research Purposes

In this study, the research team will focus on two main purposes:

(1) According to the position and needs of medical personnel's clinical conditions, design and develop a medical-patient APP, an APP for medical-patient interaction is designed to

facilitate patient input and records, provide medical personnel with understanding of patients' conditions.

(2) It is not easy for medical personnel to read and correlate a large number of databases with text records only. Therefore, the team customs information visualization to assist medical personnel to image patient data, so as to facilitate medical personnel to interpret the correlation of medical records and use them for research.

The purpose of information visualization is that the radiotherapy department will study the condition of the area and use a large number of cases to analyze the distribution of cancers in the area or city for radiotherapy to count the cases and cancer rankings. More in-depth study can include the patient's occupational experience and living habits, and even the details of diet and sleep. This information needs to be interviewed and recorded case by case, and most of the hospital's record system and data presented by text and number. The main design of this research is using the APP as a carrier to convert more in-depth data by visual images and distributions to assist medical personnel in this type of research. The visual information is easier to read and analyze through the continuous distribution of the time period. The growth and decline with changes of cancer types in the district or city can be interpreted.

2. Literature Review

2.1 The Change and Importance of the Medical-Patient Relationship

Some experts conducted semi-structured interviews with medical personnel (Grünloh et al. 2018) and found that there are two important aspects of the medical-patient relationship: (1) "role" and (2) "participation". Physicians define their role as taking responsibility for giving patients the right treatment. In the role of the patient, who lacks medical knowledge and cannot participate in the process, physicians gradually treat the patient as a static entity, ignoring their potential to develop knowledge over time. The research of Anvuur & Kumaraswamy (2016) shows that between medical personnel and patients, trust and respect for medical personnel can lead to more effective communication between the two parties, and effective communication and trust can improve the role gap, achieve the goal of joint cooperative decision-making.

With the improvement of education standards and the rise of chronic diseases and lifestyle habits, these risk-bearings are shifted from medical personnel to patients (Hanganu et al. 2020), and patients need to have more medical knowledge and health awareness. Chronic causes are long and difficult to treat, and the medical environment contributes to negative attitudes toward medical personnel, and long-term good communication is the key to the management of these lesions (Campbell and McGauley 2005).

2.2 Relationship and Influence of Medical Personnel and Patients

For many patients, the first day of radiation therapy is a period of high anxiety (Dong et al. 2014). However, when the medical personnel can effectively convey the message, it can significantly reduce the patient's anxiety (Halkett et al. 2009). The use of terminology and unclear medical terms for interpretation (Pieterse et al. 2013) can lead to patient misunderstandings and may create confusion and fear (LeBlanc et al. 2014). Radiation therapy entails explaining complex techniques to patients, and radiation therapists (RTs) performance an important role in providing information and emotional support to patients. Patients are less likely to experience anxiety and emotional distress when information is clearly communicated with minimal technical jargon and tailored to their level of understanding (Halkett et al. 2008). Conversely, patients have the potential to better understand the content of their daily treatment and effectively manage the associated side effects.

Emotional communication by medical personnel has the function of supporting the patient (Ommen et al. 2008) and is particularly effective in situations where the individual patient lacks control (Uchino et al. 1996). Emotional communication by medical personnel is a form of emotional support that can have a direct or indirect impact on the stress process (Viswesvaran et al. 1999). Positive emotions, in turn, can effectively mitigate the negative effects of stress (Garland et al. 2010).

2.3 Information Visualization of this Article

Massive big data cannot be analyzed which is sorted and differentiated only by the human’s eye and brain. Through the information visualization, diagrams can be generated and easier to read, then discover the correlation of the data (Brath & Jonker, 2015).

Big data requires advanced and suitable analytical techniques to extract valuable information, it cannot generate value if it can’t be used effectively. However, information visualization is a good way to process data. It is able to increase the readability of data through charts, and discover the content that is difficult to understand or expert in the data. For example: in the case of “plentiful information but unable to directly expert” at the psychological level, the information visualization helps to effectively connect big data and visualize information, which will become more and more important in the era of information explosion (Martens & Turk, 2003).

This study furthermore refers to the newer visual architecture of visualization researchers (Shih et al. 2022):

(1) Uses the d3.js tool for visualization: the database is encoded into a visual image.

(2) Then it is analyzed whether the visualization corresponds to the research.

(3) Situation: Analyze and feel the information expressed by the visual image; finally discover. the unexpected potential information in the past through visualization.

2.4 References of Human-Computer Interface and Information Visualization Applied on Medical-Patient

Now these days, when more and more intelligent carriers are involved, it is convenient to start interactive behaviors through the mobile interface, and it can also respond to various situations in a relatively real-time manner.

The emergency room of various hospitals is always overcrowded. People who come to the emergency room are easily lost because of the complex environment of the hospital, which also makes the emergency room more congested. In this study, the mobile device's Bluetooth system is combined with the hospital's medical information system to implement an indoor navigation function, allowing users to clearly know their current location and how to get to their destination, and allowing medical personnel to track the patient's location in the emergency room at any time (Hsu 2017). The navigation function of the system can solve the problem of people who do not know the area getting lost, and combined with an independent communication platform, it can interact with doctors and nurses.

2.5 Summary

The use of the human-computer interface, in addition to solving the problems of medical diagnosis and treatment in medical institutions and unclear visual indicators, the main purpose is to enhance the patient's sense of security through the interaction of the human-computer interface, and to improve the relationship between medical stuff and patients. Improving the relationship between medical stuff and patients through human-computer interaction, it can develop the communication willingness of each other and increase the frequency of expression, thus it can be applied to the standpoint of this study.

3. Research Method and Medical-Patient Interactive System Design

In this research, the main development object of system is the medical personnel of the radiotherapy department, and the patient is the auxiliary object.

3.1 Research Conditions and Scope

This research is based on the position of medical personnel, also takes the using of medical personnel as priority. The research is first stage of the series, focusing on the role, position and problems of medical personnel. The analysis and needs of medical personnel are presented as much as possible in the content. The interface design and discussion of the patient part will be detailed in the next stage, through the Focus Group Interview to summarize patient information, converting it into a closed option for patients to fill in, then combined with open question feedback and log recording, which can significantly reduce the burden of the input process when patients are weak after treatment.

3.2 UI & UX Design Specification

The whole testing prototype was designed by Adobe XD and Figma, with the official IOS system rule as the main target, and the design criteria is IOS 13. In addition, in terms of UI and UX design architecture, this research is based on “Multiscreen UX Design: Developing for a Multitude of Devices (Wolfram, 2015) and “Observing the User Experience: A Practitioner's Guide to User Research (Goodman & Kuniavsky, 2012)”. Conclusively, the visualization part is based on “Beautiful Visualization (Steele & Iliinsky, 2010)”.

3.3 Focus Group Interview and Persona

At the first step, research team go through the focus group interview, observation, induction and analysis, we set up characterizations of actual problems. Through this method, we can predict the behavior patterns of users, and then have a deeper understanding of the needs and differences of users, and can better identify potential user’s problem specific.

The main object of this system is the medical personnel, research team analyzed the personalities of medical personnel through characterization, and Fig.1 shows the key excerpts of the differences in persona, including: (1) occupation (2) work experience (3) areas of expertise (4) goals and needs.

The leading entry point of the persona is that the number of patients who need to be treated by medical personnel is large, it is impossible to deeply understand their problems and statuses individually.

3.4 The APP System

System development is based on functional maps. The users who can interact in the function map have corresponding items that can be input and output (Fig. 1). As can be seen from Fig. 2, the solid line part is the main function structure and the distribution of function pages; and the dotted line part is the interaction correlation between the functional pages of users.

Fig. 1 Input and Output of Medical-Patient System

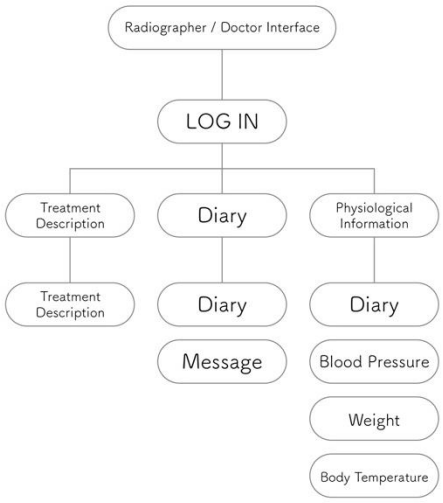

Fig. 2 Functional map

3.5 The User Interface

The idea is that people can visualize parts of the design process to understand their thought process and create precisely, an insightful abstract logic of the design alternatives they might have at a particular stage. In order to externally visualize the internal design process and be able to understand the logical thinking at a particular point in the time frame, this study proposes a recording system called the Visual Internal Processing Graph.

After all the pre-work and the design framework are completed, the next step is going to do the prototype development of the system. At the beginning, set the function keys and page distribution required by this system to set the wireframe, then configure the operation flow of UI, and conclusively import the complete visual design into the system.

The sequence of using the system is as follows (Fig. 3 & 4):

(1) The medical personnel enter the system and log in.

(2) The system displays the list of patients undergoing treatment today (the list can also be selected according to the date).

(3) Enter the system to view the patient's treatment course and condition (the system has a note of medical order, confirm whether the patient has any physical or psychological conditions).

(4) Confirm the progress and content of the patient’s treatment (whether to increase or decrease the dose, or to add medicine).

(5) If the patient has any information, make reply and observe the record (confirm whether there is any problems and emergencies).

(6) Observe and record whether there is any physical discomfort before and after radiotherapy.

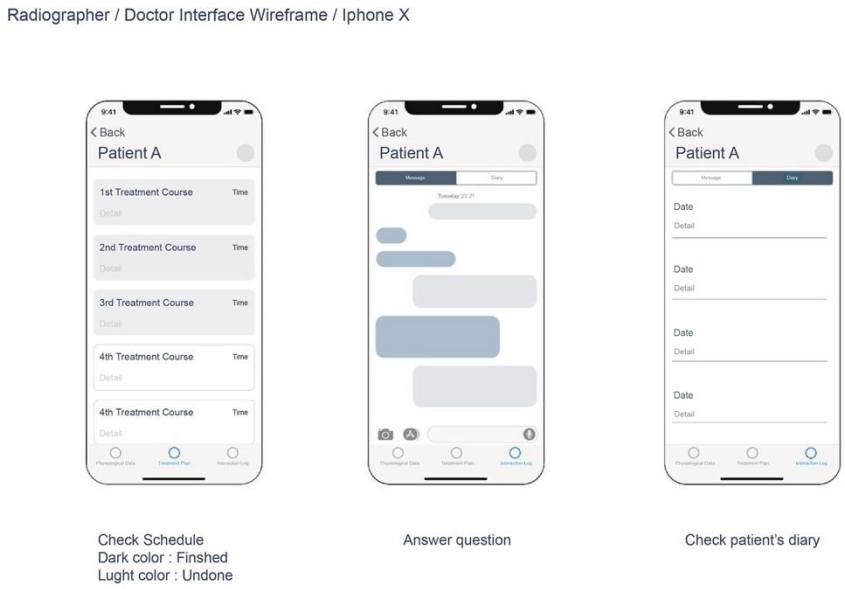

Fig. 3 User interface (Part)

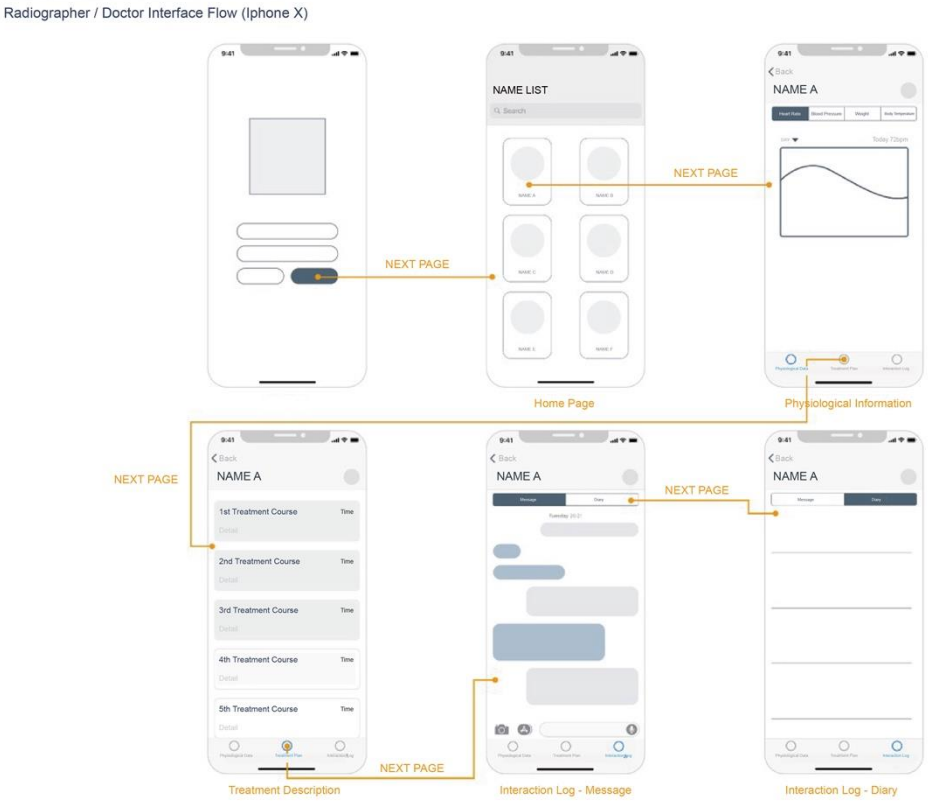

Fig. 4 User interface flow (Part)

3.6 Experimental Subject, Time, and Location

This study was carried out in the Department of Radiation Oncology, FAR EASTERN Memorial Hospital, New Taipei City. The number of people involved in the experiment was: 6 doctors, 11 radiologists, and 20 patients (patients' data will present in next stage)

In addition, due to the impact of the epidemic, the experiment period was extended from October 2021 to June 2022, and the experiment location was in the meeting room of the Radiation Oncology Department.

3.7 Situational Task Testing of APP System

The setting of the situational task was decided after four times expert meeting discussions. The participating experts came from medical (doctors and radiologists), UI design, UX design, and information fields. According to the content of the course of treatment, the expert meeting conducts personage simulation and user experience to make situational task sub-items. The sub-items of each situational task are based on the Likert scale, and then item decided by experts in each field rating task is easy, medium, or difficult. In the end, the average of all expert scores is used to determine which level the task belongs to. The two sides of the test refer to the correctness of both the doctor and the patient, the fluency of operation, the reading style, and the consensus. After the results of the initial interviews and simulation tests between the medical personnel and the patient, the results are corrected and adjusted by the expert meeting before reaching the final level. The prototype test of this research content, and all designs of this prototype are carried out in accordance with the official settings and specifications of the official IOS system rule.

4. Testing and Result of Interactive System

At present, the research has designed a basic prototype interface, which can be used for experimental testing and process operation, so as to collect feedback and responses, and make corrections and adjustments (Fig. 5). The situational task test is as follows, and is divided into easy, medium, and difficult levels:

(1) Check out this week's announcements after entering the homepage.

(2) After viewing this week's notifications, want to see the distribution of notifications from previous weeks.

(3) Going to a past date when viewing weekly notifications and needing to go back to today's date immediately.

(4) If you see this week's notifications on the date dial on the homepage, you need to check what notifications are added today.

(5) Since it is too difficult to view the newly added data of patients one by one, it is necessary to know which patients have updated the data in a chronological order.

(6) Check the data of each patient's physiological information.

(7) Check the progress of each patient's treatment, and compare the progress of treatment and. recovery to make medical records.

(8) Check the notification and see that the patient has sent a message and must respond as soon as. Possible.

(9) Routine observation of patients' emotions and thoughts to obtain psychological information that. data cannot show.

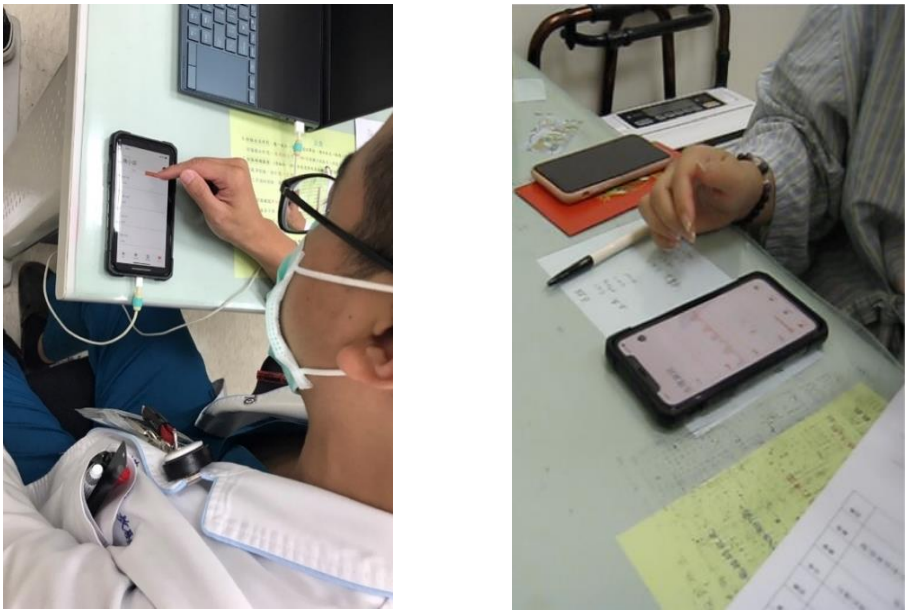

Fig.5 Testing task for medical personnel (main) and patient

The purpose of the test of this interactive system is to directly record and analyze whether the operation of the system is smooth and intuitive through the actual use of users, and to observe whether the presentation and instructions of the interface conform to the reading styles of both users. The usage context and task are set up, the context and task are structured according to the function map and the user journey map, so the page sequence of the system and the proper design of the function buttons can be obtained from the user experience.

The interface has been used for experimental testing to facilitate the collection of feedback and responses, and to make corrections and adjustments. After the systematic testing of situations and tasks, the subjects gave the operation feedback, the research will classify these feedbacks, for example: the intuition of the turntable is up and down, the numbers and buttons are too small; arrows can be added; the operation is not intuitive, the text description is not enough...etc. In addition, the design and modification of the interface system after the integrated feedback is also carried out, and the feedback after the integrated classification is adjusted in the system one by one to achieve a more intuitive and comfortable operation interface.

In the study, these feedbacks were integrated and classified, and the details of the medical personnel's feedback were listed, the following conditions are listed in order of the proportion of medical personnel's feedback:

(1) The distance between the button and the input box is too close.

(2) The intuition of the turntable is up and down; the numbers and buttons are too small; arrows. can be added; the text description is too small.

(3) The notification shows the number of unread messages (in red).

(4) There are new notifications that can blink or show color to dynamically grab the user's attention.

(5) Numbers and buttons need to be increased.

(6) Compared with the newly added physiological data of the patient, the emergency notification. (Data abnormality, etc.) is more noticeable to the medical personnel.

(7) Still need return key.

Finally, this study completed the revision of the final version of the APP system, it is based on all the users' experience feedback and interview opinions after the above tests.

5. Information Visualization of Medical-Patient Interactive System

5.1 The Way of Visualization

Patient information can include: region, disease type, personal information, occupation, treatment time, response to the condition, etc. Subsequently analyzing the relevance from the above-mentioned dimensional data, the type and relevance of the data analyzed from each dimension are then mapped to a visual image suitable for presentation. This step will use the Java Script-based application "D3.js"(Fig. 6).

Fig. 6 "D3.js"

5.2 Conditions of Information Visualization

This article will start with the first part of the originally planned database: a preliminary visual presentation of patients undergoing radiotherapy in the hospital. According to the patient information collected in the hospital in this article, these patients will be treated from 2021/December and confirmed to start radiotherapy. In this article, most of the data are filtered and filtered out of the visualization that can be applied to the test in the research. Data is classified in the research based on occupation, age, cancer symptoms, cancer stage, and education level; this step is also equivalent when using a large database to retrieve data suitable for research.

After the information on the APP enters the database, in addition to viewing the content of the patient's reply from the APP, the medical personnel will also import it from the background of the database to the "PACS" medical system which commonly used by hospitals. Most hospitals in Taiwan all use this system to interpret medical records, but the system is mostly text display, and there is no real-time visual conversion. What this research is doing is to use these text data through visual program instructions ("D3.js") to create continuous image data that can be easily interpreted by medical personnel and can present time-linear and regional attributes.

5.3 Information Visualization: The Reason and Process of Sankey diagram

After data classification (or database building), consider choosing an appropriate visual image presentation theme based on the amount of existing data, classification methods, and their relevance.

According to the needs of medical personnel and focusing group discussion, the research team chooses the appropriate visualization method according to the situation in D3.js, the research team uses the data we collected for testing, we tried a variety of visual image categories, expecting to observe various types of hidden information and related links. Finally, the Sankey diagram in D3.js to display the visual distribution by moving nodes horizontally and vertically (Fig. 7).

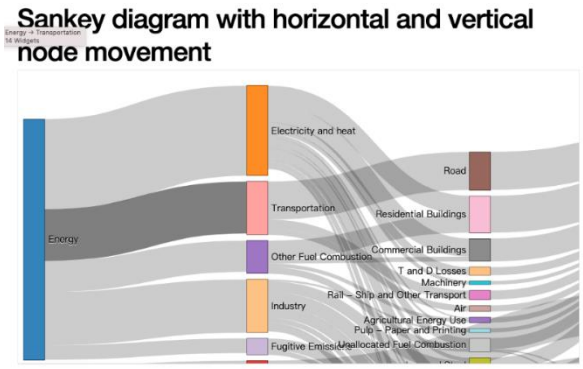

Fig. 7 Sankey diagram with horizontal and. vertical node movement

When selecting the visualized distribution map to be displayed, enter the classified database dimension through the information classify and continue the series connection. Subsequently, all the data is entered and concatenated, the selected Sankey diagram with horizontal and vertical node

movement visualization image can be obtained. Through the features of Sankey diagram, its visual image can display the condition, distribution, proportion, and correlation of patient data, and it can also link and compare information, such as which area has the most cancer proportion, and occupation or age, how great is the correlation, whether there are regional factors that affect the probability of cancer (Fig. 8).

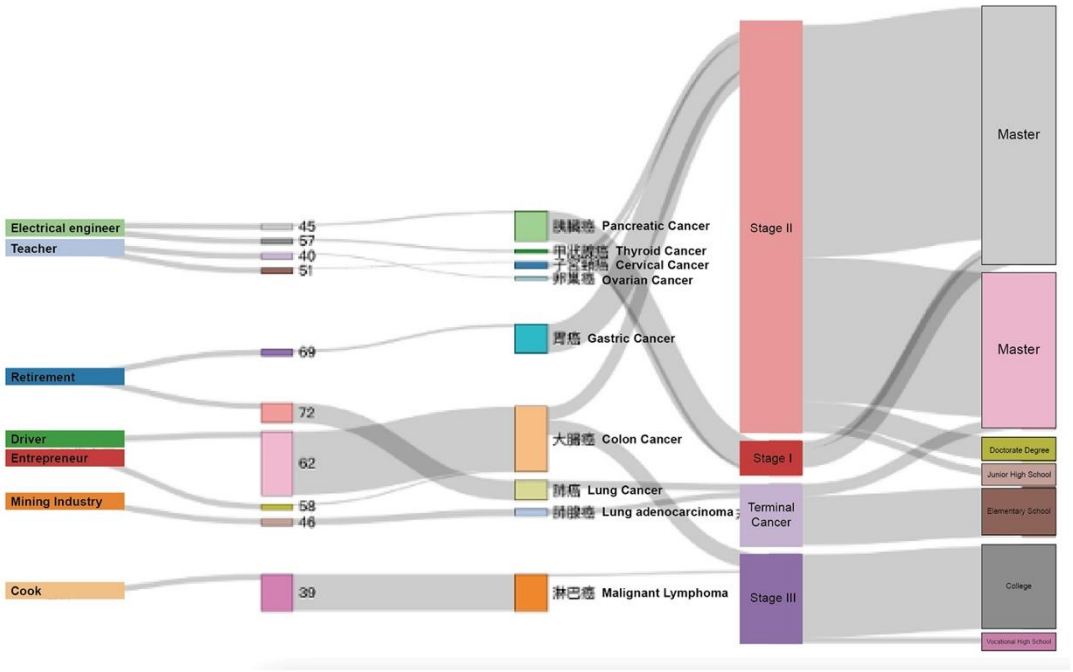

Fig. 8 Visualize the result of multiple hypothetical data

6. Conclusion and Discussion

Subsequently the initial data classification to the consequent visualization and the simulation of the hypothetical number, it can be found that the pure text brought by it is less observable relevance, especially after correcting the number of data, does not distinguish between occupations and cancer types in various dimensions and proportions, which can provide medical personnel with faster and clearer discrimination. In follow-up research, if the addition of more complete types of dimensions (such as work content, eating habits, genetic diseases, genes, lifestyle, etc.) can definitely provide medical personnel with more relevant reference materials, which can also be provided by these materials When facing patients, medical personnel can pay more attention to the factors of the condition.

In the visualization test of this study, the medical personnel mentioned that the information visualization of the preliminary test has been able to observe more related data than the document database, for example:

(1) For patients in the radiation therapy department in this study, occupational factors had a

slightly higher influence on cancer development than innate genes.

(2) In addition to common cancers caused by life style and habits, medical personnel also tell from the visual data that there is a rapid decline in the age of certain diseases, that are common in the middle and high age groups.

The medical personnel participating in the test all responded that this is a condition and relationship that was relatively unobservable in the past data.

In the process of information visualization, constant adjustments and modifications are required, including the environment settings of the pre-operations and the selected systems and platforms. It is possible that the serial channels need to be mounted for the benefit of different versions and computer systems. Follow-up: In addition, in the database establishment part, if today's research topic is carried out with massive big data, it is very important to build a set of databases that can be continuously and automatically updated from the beginning, so as to ensure that the entire system is in use It can maintain the latest information and data, and can instantly reflect the problems and solutions provided by various users around the world.

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以醫事人員觀點為放射治療之患者進行資訊視覺化設計

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摘要

在長期治療的過程中，病患的情緒及心理訊息經常被忽視或誤解，且醫事人員很難收集並理解此類資訊，以提供病患適當的建議，若能將患者的資訊或狀態進行視覺化，可以較為及時提供醫事人員參考。本研究設計一套供正接受放射治療的患者以及進行治療的放射師與醫生於臨床使用的醫病系統。透過該醫病系統和多層面的觀察，將患者的反應記錄和分析為視覺化數據。醫事人員可通過這些數據幫助患者，記錄治療，穩定患者的心理與療程；而建立患者的視覺話資料庫，也可以為醫事人員提供有價值的患者反應資訊。未來針對不同類型癌症的患者，在治療過程中可能出現的情況進行相關研究，推測患者在治療過程中各個階段可能產生的反應，可以作為醫事人員相當可靠的依據。

關鍵詞：醫病關係、資訊視覺化、醫病互動系統、放射治療、D3.js