

**The Potential of  
Using Virtual Reality Technology  
in the Treatment of  
Post-traumatic Stress Disorder in  
Female Breast Cancer Patients in China**

Mingyang SUN

A research Paper submitted to the University of Dublin, in partial fulfilment of the requirements for the degree of Master of Science Interactive Digital Media

2020

## **Declaration**

I have read and I understand the plagiarism provisions in the General Regulations of the University Calendar for the current year, found at: <http://www.tcd.ie/calendar>

I have also completed the Online Tutorial on avoiding plagiarism 'Ready, Steady, Write', located at <http://tcd-ie.libguides.com/plagiarism/ready-steady-write>

I declare that the work described in this research Paper is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

Signed: \_\_\_\_\_

Mingyang SUN

14/05/2020

**Permission to lend and/or copy**

I agree that Trinity College Library may lend or copy this research Paper upon request.

Signed: \_\_\_\_\_

Mingyang SUN

14/05/2020

## **Acknowledgements**

I would like to express my deep appreciation for my supervisor, Diana Wilson, and in particular for her encouragement and guidance during the writing of this research paper. I also wish to express my thanks to my father and stepmother who have supported me to chasing my dream of studying at Trinity College Dublin. Furthermore, I would like to show my appreciation for my classmates, friends, and lecturers and professors in my master's programme for the achievements and knowledge that I could not have gained without all of them.

## Summary

Breast cancer has become one of the most serious diseases threatening women's health. Although current medical technology can mitigate the harm caused by breast cancer, the psychological damage to patients cannot be ignored. Since breast cancer leads to changes in women's bodies and secondary sexual characteristics, many women will experience psychological illnesses after treatment. Of these, post-traumatic stress disorder (PTSD) is one of the most serious. This paper examines the introduction of virtual reality (VR) technology into the treatment of PTSD in breast cancer patients and explores the feasibility of this approach.

The main research methodologies adopted in this paper are literature research, case analysis and interdisciplinary research. Through the in-depth study of breast cancer and VR technology, this paper concludes that it is feasible to apply VR technology to the post-traumatic stress treatment of breast patients, with clear therapeutic effects. However, it is worth noting that current VR technology does not perform better than traditional treatments, although it has greater efficiency.

In general, it is feasible to introduce VR technology into the treatment of PTSD in breast cancer patients, with positive significance for the treatment of such patients. VR technology offers a sense of reality and immersion that traditional therapy cannot achieve. This paper also makes suggestions for the future development of VR technology in PTSD treatment.

## Table of Contents

<b>Acknowledgements .....</b>	<b>III</b>
<b>Summary.....</b>	<b>IV</b>
<b>Table of Contents .....</b>	<b>V</b>
<b>List of Figures.....</b>	<b>VII</b>
<b>List of Abbreviations .....</b>	<b>VIII</b>
<b>Chapter 1 Introduction .....</b>	<b>1</b>
1.1 Background.....	1
1.2 Research Aim.....	3
1.3 Paper Structure.....	4
<b>Chapter 2 Virtual Reality.....</b>	<b>5</b>
2.1 Realizing Virtual Reality Interactions .....	5
2.1.1 Virtual Reality Realization Tools .....	6
2.1.2 Content Creation .....	6
2.1.3 Environmental Design .....	8
2.2 Applications of Virtual Reality.....	9
2.3 The Development of Virtual Reality in China.....	10
2.3.1 Politics .....	10
2.3.2 Economics.....	11
2.3.3 Society.....	11
2.3.4 Technology .....	12
2.4 Summary .....	12
<b>Chapter 3 Breast Cancer and PTSD .....</b>	<b>13</b>
3.1 Breast Cancer and Treatment.....	13
3.2 Mental Health of Chinese Female Breast Cancer Patients .....	13
3.3 PTSD Symptoms in Breast Cancer Patients .....	15
3.3.1 PTSD Symptoms.....	15
3.3.2 PTSD Symptoms in Breast Cancer of Patients.....	17
3.4 Traditional Therapy for Breast Cancer Patients' PTSD Symptoms .....	19
3.4.1 Development of Cognitive Behavior Prevention Treatment .....	19
3.4.2 CBT and PTSD for Breast Cancer Patients .....	20
3.4.3 Disadvantages of Cognitive Behavior Prevention Treatment.....	21

3.5 Summary .....	23
<b>Chapter 4 VR Technology for Treating PTSD in Breast Cancer Patients</b> .....	<b>24</b>
4.1 Applying Virtual Reality in PTSD Treatment .....	24
4.2 Virtual Reality Exposure Therapy .....	25
4.3 VRET in PTSD Treatment.....	26
4.4 Comparison of VRET and Other Treatments for PTSD.....	27
4.5 Advantage of VRET .....	28
4.5.1 Reality .....	28
4.5.2 Practicality .....	28
4.5.3 Customization .....	29
4.5.4 Privacy .....	29
4.6 Potential of VRET in Treating Breast Cancer Patients' PTSD Symptoms .....	29
4.7 Advice for Using VRET in Breast Cancer Patients' PTSD Treatment .....	31
4.7.1 VRET Emphasis.....	31
4.7.2 Scene and Narrative Creation .....	32
4.8 Outlook for VR Technology in Treating PTSD in Breast Cancer Patients .....	33
4.9 Conclusion .....	34
<b>Chapter 5 Conclusion</b> .....	<b>36</b>
5.1 Conclusion .....	36
5.2 Research Contribution .....	37
5.3 Research Limitations .....	37
5.4 Future Work.....	38
<b>Reference list</b> .....	<b>39</b>

## List of Figures

Figure 1.1 <i>Incidence rate and morality rate of breast cancer patient in China</i> .....	2
Figure 2.1 <i>How virtual reality interaction works</i> .....	9
Figure 3.1 <i>CBT in breast cancer patients' PTSD treatment</i> .....	21
Figure 3.2 <i>The type of CBT treatment</i> .....	22
Figure 4.1 <i>Three stages of PTSD treatment</i> .....	26



## List of Figures

AR	Augmented Reality
CBT	Cognitive Behavior Therapy
CT	Cognitive Therapy
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
EMDR	Eye Movement Desensitization and Reprocessing
LM-GM	Learning Mechanics to Game Mechanics
PCL-C	PTSD Checklist-Civilian Version Scale
PE	Prolonged Exposure
PTSD	Posttraumatic Stress Disorder
SIT	Stress Inoculation Training
VR	Virtual Reality
VRET	Virtual Reality Exposure Therapy

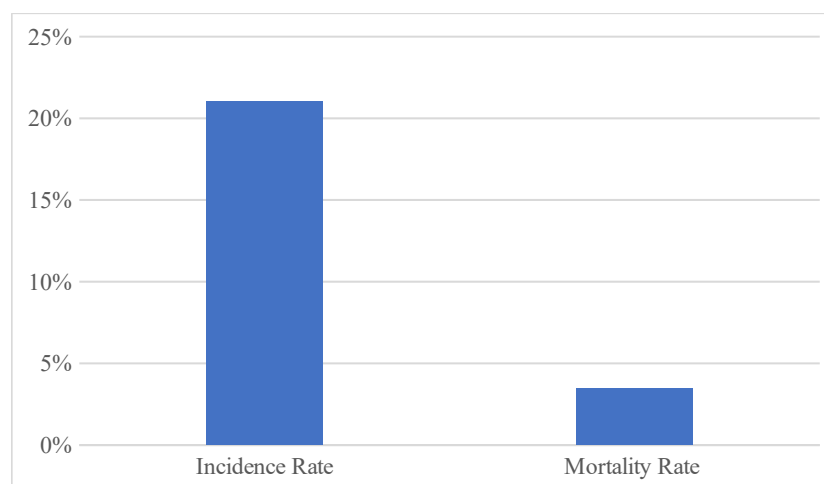
# Chapter 1: Introduction

## 1.1 Background

Cancer is the second most common cause of death and a cancer diagnosis can change a person's life (Wild, Weiderpass, Stewart, editors, 2020), affecting not only the patients themselves but also their friends, family and colleagues. The impact may involve economic, emotional and mental effects on patients, as well as other effects brought about by the cancer itself, such as PTSD, which may afflict patients from the moment of their diagnosis. Even if they complete the treatment, they may continue to suffer from sequelae, such as PTSD. However, these sequelae or side effects are often ignored by doctors, patients and patients' families, because traditional cancer treatments usually involve physical therapy rather than psychological therapy. If cancer patients have mental health problems, they should seek help from a psychologist, not their oncologist.

Of the types of cancer, breast cancer has its own characteristics. However, the mental problems arising from breast cancer are usually treated similarly to those of other cancer patients, which may cause a worsening in the mental state of breast cancer patients. Thus, the mental health of breast cancer patients deserves more attention. Breast cancer is one of the deadliest cancers and has the highest incidence rate among women worldwide (Neta, 2020). According to the 'World Cancer Report' published by the International Agency for Research on Cancer in 2020, breast cancer caused 627,000 deaths and at least 2.1 million new cases in 2018 (Wild, Weiderpass and Stewart, 2020). According to a report by the Global Cancer Observatory, breast cancer is one of the most common cancers suffered by women, with an age-standardized rate of 21.6 per 10,000 people (Ferlay, 2008) and a mortality rate of 3.44 per 10,000 people (Yuan, 2018). As one of the malignant tumors that appears in women, especially in China (Li, Ma, Li and Zhou, 2015), its incidence already ranks first among urban women. According to Green and Raina's research (2008), due to epidemiologic and biologic differences, women from the Asia-Pacific region (including China) are more likely to contract breast cancer than Western women. In addition, the combination of Asian physical characteristics with a more Western lifestyle could be another contributing factor to breast cancer. According to data from 'Global Cancer Statistics' (Parkin et al., 2002) and 'Spectrum of Breast Cancer in Asian Women' (Agarwal et al., 2007), China has the highest incidence and second-highest mortality of Asian countries.

This is due to China's unique economic and cultural situation from which arise related challenges such as medical treatment, diagnosis, management, and even misperceptions of the disease itself. According to research conducted by Li Yuxiang, a doctor in China, 85.1% of breast cancer patients will suffer from PTSD symptoms (Li, n.d.). This is a considerable proportion of the population; therefore, this topic is worthy of further research. In addition, mental state is one of the causes of breast cancer (Jasmin et al., 1990). Consequently, PTSD symptoms are an important indicator for the treatment of breast cancer. If doctors ignore PTSD factors in the treatment process, the patient's condition may worsen. Therefore, it is necessary to incorporate PTSD symptoms into breast cancer treatment.



*Figure 1.1 Incidence and mortality rates of breast cancer patients in China*

The psychological condition of breast cancer patients is usually ignored or treated similarly to that of other cancer sufferers, with a negative effect on breast cancer patients' mental state as well as their treatment outcomes. For societal and cultural reasons, some female patients will feel uncomfortable talking about their breast cancer when they need psychological support. Even after they are fully recovered physiologically, they may still feel that their life is not as same as before and experience new psychological symptoms. When these symptoms occur, most sufferers try to deal with it by themselves or even try to hide it. This phenomenon is obvious in China. Fatalism and a belief in karma are two significant reasons why many Chinese women are disinclined to talk about their breast cancer with other people. From the perspective of Chinese fatalism, cancer is considered to be karma and there is a philosophical doctrine that explains that nothing can prevent karma from happening. Hence, when Chinese people contract cancer, some of them consider it to be a type of karma and so they believe that they deserve it

and consequently do not submit to treatment. In an interview-based study (Mo, 1992), more than one Chinese woman claimed that she was ashamed to talk about the disease with other people because the body is too private to discuss. In addition, cancer is usually associated with death in Chinese culture and it is a taboo to talk about either death or cancer in normal conversation (Wong-Kim et al., 2005). According to research into cancer-related beliefs, for cultural reasons, some Chinese people believe that cancer is contagious (Topley, 1958) and that bad luck is one of the reasons for contracting breast cancer (Wolf and Witke, 1975). In addition, sex education is considered to be an inappropriate topic and private parts such as breasts are a taboo. Thus, when it comes to breast cancer, some Chinese woman will try to avoid talking about it because their cancer is a taboo in Chinese culture (Mo, 1992). Cultural beliefs and social constraints also have negative consequences for recovery, even potentially leading to a relapse if breast cancer sufferers experience anxiety, depression, or other post-traumatic stress related responses.

With respect to treating the PTSD symptoms caused by breast cancer, the development of VR technology positively impacts treatment effectiveness. At present, VR technology has been gradually applied to some PTSD treatments, with an obvious effect. There are already successful cases of VR technology being applied to PTSD treatments, for example in exposure therapy for the World Trade Center survivors. According to the Clinician Administered PTSD Scale, 90% of PTSD symptoms have been reduced with the help of VR technology in psychotherapy. Thus, the application of VR technology in the treatment of PTSD is worthy of further research (Difede and Hoffman, 2002), especially in breast cancer treatment.

## **1.2 Research Aim**

The application of VR in the field of medicine has broad developmental prospects (Sun, Yan and Li, 2007) and provides a new way of treating patients and a new path towards recovery. It has already seen considerable success in the treatment of mental health, for instance, Botella's treatment plan for claustrophobia (Garcia-Palacios et al., 2002) and the VR exposure treatment of American veterans of the Iraq war (McLay et al., 2011). VR allows patients to immerse themselves in a virtual environment and give them a sense of reality (Burdea and Coiffet, n.d.). However, there has been little research about women suffering from PTSD, especially those who suffer from PTSD as a result of treatment for breast cancer. Since this is a special

demographic of affected women, the question of whether VR technology can be used to help them is worth studying.

This study aims to help women with PTSD symptoms recover from breast cancer treatment in a Chinese context. With the help of VR technology and real-time image processing technology, women can experience a virtual environment that may contribute to recovery from the diseases they are suffering. Moreover, the virtual environment could even be fully integrated, enhancing the sense of reality in the human consciousness, which may be helpful for alleviating PTSD symptoms following breast cancer treatment. On this basis, this paper discusses the possibility of employing VR technology in the treatment of women with PTSD symptoms caused by breast cancer.

### **1.3 Paper Structure**

This paper is divided into five chapters examining the application value and potential of VR technology in the treatment of women suffering from PTSD as a result of breast cancer. The main research methods are literature research, interdisciplinary research and case study.

Chapter One, discusses the research background, significance and purpose of this paper.

The second chapter introduces the concept and characteristics of VR and the way in which it can be applied to the medical field.

In Chapter Three, the status and characteristics of PTSD symptoms after breast cancer treatment in China are studied.

Based on the analysis in Chapters One to Three, Chapter Four discusses the possibility of applying VR technology to the treatment of PTSD in female breast cancer patients.

Finally, Chapter Five summarizes the paper and discusses the shortcomings of the application of VR technology to the treatment of PTSD symptoms in female breast cancer patients. In addition, based on the development of VR technology, the author offers some personal views and prospects for the future.

## **Chapter 2: Virtual Reality**

VR technology uses computers to model the real world and simultaneously create a virtual world, and is also called awareness anesthetic (Lou, 2017). The computer analyzes complicated information and conducts visual operations while the user interacts with the computer.

VR technology not only reflects the real world but also allows people to enrich their experience of the real world in which they live. It is a new module of human-computer interaction and, compared with traditional human-machine interactions and operating systems (Frank and Mark, 1995), VR technology is vastly different because it gives users an immersive, interactive experience that cannot be emulated by traditional human-machine interaction (Biocca and Levy, 1995). Since VR technology involves many areas such as education, medical training, entertainment etc., its potential deserves further research.

### **2.1 Realizing Virtual Reality Interactions**

A VR system has the following three characteristics that differentiate it from similar technologies: interactivity, imagination and immersion. Interactivity means that users can naturally interact or communicate with objects in the virtual world. Imagination, in this context, refers to the fact that the virtual environment allows users to immerse themselves, acquire new knowledge and improve their perceptual and rational knowledge, in order to stimulate new ideas. Finally, immersion reflects the fact that the computer-generated virtual world enables users to feel as though they are in a real objective world (Biocca and Levy, 1995). The most important of these characteristics is immersion, which comprises three factors: graphics, interactivity, and action, which are key to effective immersion (Bowman and McMahan, 2007).

The realization of VR depends on the creation of the virtual world, the user's life experiences and the design of the user interface (Understanding Virtual Reality, 2020). The process for this is as follows. First of all, a VR system uses interactive objects to create a navigable virtual world. Second, a camera is used to capture each object at different angles and electronically wrap the image around the object. All the transferred data that are acquired from analysing the captured picture are recorded in the database, which is used for machine-learning movement sample storage. Third, the user's movements are recorded and these data are stored. Fourth, the

object and user's overlapping features can be added to the image to generate a new image. Finally, the VR application program corrects any image distortion and changes the angle according to the user's movements, sending the image back to the user (Kanade, et al., 2000).

VR technology can be used to influence users' emotions, actions and behaviors with greater effect than other technologies, as long as the VR creator truly understands the way in which VR design should be applied and used. With respect to VR applications for treating PTSD, certain details should be given particular consideration when designing the virtual world. Here, the tools for realizing VR, content creation and the design of the virtual environment are examined in greater depth.

### **2.1.1 Virtual Reality Realization Tools**

The user interface is composed of software and hardware realization. Software realization usually refers to visual generator realization and sometimes includes the software interface programming of the sensor. Hardware realization, meanwhile, refers to the comprehensive settings and programming of various types of effects equipment, such as a data helmet, stereo phone and sensor. The process of realizing the VR world is the basis of graphic software design. Thus, the means of realizing VR refers to virtual graphic interface realization.

The software used to realize the VR includes three-dimension simulation production software and auxiliary tool software, while programming languages used for this include VRML, Java 3D and VC++. The simulation software commonly used for three-dimension modeling are Creator and Vega, made by MultiGen, the basic software used are OpenGL, DirectX and Open Inventor, and the professional software include WTK and VRP. Auxiliary tool software such as VC++ or AutoCAD can be employed to create different types of virtual scenes based on the needs of the user or the virtual world. For example, the creator can use OpenGL or VC++ to create a virtual venue visiting system or VRM or Java 3D to create a campus display system (Brutzman, 1998).

### **2.1.2 Content Creation**

Content is clearly important in the creation of a virtual world. Without content, users will quickly become bored with the virtual world, and it is difficult to follow up the subsequent

virtual world narrative. Furthermore, if the user does not have the sensation of being fully immersed or integrated in the virtual world, they will not have an effective experience when using VR technology. Content creation is related to the user's life experiences, including memory, abilities, emotional state and cultural background. Based on these aspects, the creator aims to build an appropriate and comprehensive storyline or gameplay for use in psychological treatment (Sherman and Craig, 2003).

Experience fidelity and skeuomorphism, that is to say, when the object or symbol shown on screen is similar or almost the same as the version that exists in reality, are two key indicators of design content. According to the user's experiences, the story that unfolds in the virtual world can be intensive or slow, because users must employ their imagination to understand and connect the story of the virtual world. In addition, the user experience is a filter; when users are in the virtual world, they contribute their own values, insights and perceptions to their understanding of the story. This can result in users thinking or acting in a way that was unanticipated, or even unwanted, by the creators of the virtual world. Skeuomorphism can help users quickly and naturally understand and learn how to interact with the virtual world, thus isolating them from the real world as quickly as possible. The longer it takes users to immerse themselves in the virtual world, the worse the impact of the virtual world will be.

The phrase 'core experience' is used to refer to the feeling engendered in users when they are in the virtual world. Achieving this requires that the narrative of the virtual world stimulate users' interest and retains them in the storyline throughout the experience. Therefore, the game mechanism and content must be well designed.

The logic of the virtual world should be reasonable and comprehensible, in order that users can immediately integrate and start exploring the virtual environment. Usually, VR environments are designed by teams, with each team member fulfilling a different role. Therefore, it is vital to have a director that oversees the design as a whole. When creators are in the middle of constructing or designing something, their thoughts are likely to be limited to the world that they are building, ignoring other aspects and problems of the overall design. A director is, therefore, necessary to identify any content or design that is lacking in coherence, consistency or uniformity.



### **2.1.3 Environment design**

The design of the virtual world should be closed, with a focus on immersion, the user's perspective, the venue, simulations and objects. The scene, color and lighting, audio, sampling (which is when the VR creator has to choose the most representative object as the sample so that users recognize the object. For example, in a normal context, the VR creator could not use a car model as a sample to create a mushroom) and aliasing (which refers to rendering a model to a virtual object and includes rendering the texture of the object) and environmental wayfinding aids are the basic aspects of designing the virtual world. To create the scene, the background, contextual geometry, fundamental geometry and interactive objects must be taken into consideration. Furthermore, color plays a particularly important role in design since colors have strong connotations, which may differ between cultures or countries.

Audio can contribute to the virtual scene and help users better immerse themselves in the virtual world. For example, the sound of a wave is likely to be associated with the sea and the beach. George Lucas (2011) states that sound is 50% of the motion picture experience, so neuralization, spatialized audio and head-related transfer function are the basic aspects of the auditory experience.

Finally, environmental wayfinding aids refer to guiding the user to the right place or ensuring that they find the right goal. When a user first enters a virtual world, they can easily get lost if they are unfamiliar with the environment. In particular, for virtual worlds that are created specifically for treatment, if users get lost or are poorly guided, they may be unable to experience the whole virtual world and thus will have a sub-optimal treatment experience (Jerald, 2015).

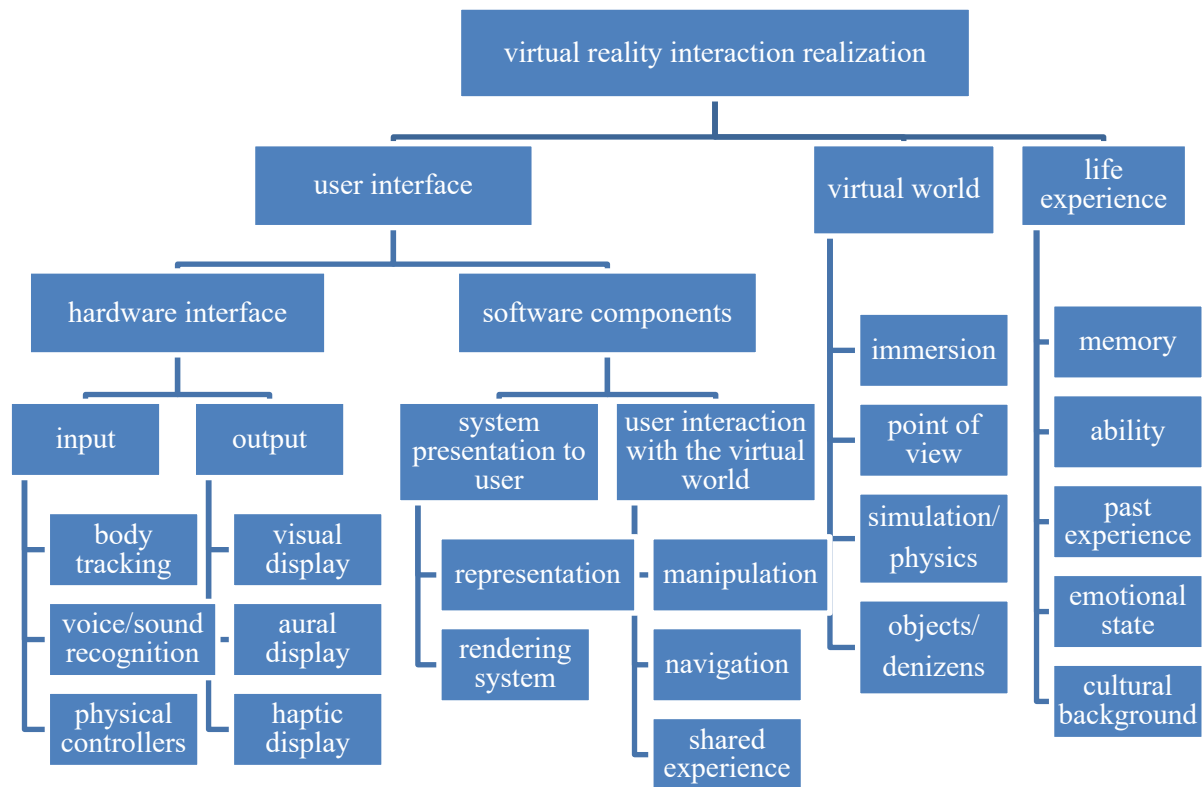


Figure 2.1 How virtual reality interaction works (Sherman, W. and Craig, A., 2003)

## 2.2 Applications of Virtual Reality

The current research and application fields of VR include the military, medicine, education, scientific research, entertainment and engineering. Typical VR products include Google Board, Samsung Gear VR on mobile and Oculus Rift for PC (Zhang and Su, n.d.). The uniqueness and potential of VR technology has been recognized by both researchers and clinicians (Rizzo et al., 2013) and it has been successfully applied in countries including America, UK, and Japan to industrial visualization, games, military training simulations, and in other fields.

In particular, in the field of medicine, there are numerous successful cases of the application of VR technology to medical treatments. For example, Makoto Yoshizawa's team applied VR technology to treat hypoesthesia (Baheux et al., 2006). According to Walter Greenleaf (2019), one of the first people to apply VR technology to medical treatment, VR can be applied in four areas of medicine: medical training, clinical diagnosis, prevention and healthcare. Although VR technology cannot cure patients directly, it can help alleviate chronic pain and

physiological stroke trauma through its immersive nature. Additionally, immersion in a virtual scene can distract patients, thus, VR technology is also called awareness anesthetic. Intel has already begun to cooperate with Surgical Theater, one of the top companies engaged in the application of VR in medical treatment. Furthermore, Medical Realities, the world's first end-to-end immersive platform for the healthcare industry, is dedicated to developing VR and augmented reality (AR) systems for medical training purposes. At the same time, EchoPixel is trying to use VR technology to rebuild pictures of organs to improve the preoperative preparation of surgeons. Through the application of VR technology in the field of medicine, the author preliminarily believes that it is worthwhile to study the application potential of VR technology in treating the PTSD symptoms of breast cancer patients in China.

As one of the most important fields of modern medicine, psychology is being increasingly linked with VR technology. VR technology research in psychology includes visual, physiological, psychoacoustic, physiological, memory and cognitive psychology. Between the human cognitive processes, including touch, sense, memory, thinking and imagination, psychology is one of the most important subjects in research into physiological treatments (Riva, 2009). With the help of virtual technology, visual and auditory systems can be used in psychological research.

## **2.3 The Development of Virtual Reality in China**

As the development of VR technology in China has exceeded expectations, this section will adopt a PEST analysis model to examine the development of VR technology in China and its potential for application in the treatment of breast cancer patients with PTSD.

### **2.3.1 Politics**

According to the *Virtual Reality Industry Development White Paper* published in 2019, China will focus on developing 5G, artificial intelligence and the cloud in VR research. In addition, according to the 'Outline of the National Medium- and Long-term Scientific and Technological Development Plan (2016-2020)' published by the Chinese government, the emphasis in VR technology will combine electronics, psychology, cybernetics, computer graphics, database design and real-time distribution systems. Furthermore, VR technology applications are anticipated in medical, entertainment, education, military and industrial manufacturing areas,

among others. In addition, the Ministry of Industry and Information Technology of the People's Republic of China has published 'Guidance for Speeding up the Development of the Virtual Reality Industry', which mentions education in VR technology as being critical for the industry's future. In summary, these policies demonstrate the determination of the Chinese government to support the development of VR technology in China. Consequently, VR technology has a clear development space and receives considerable attention in China.

### **2.3.2 Economics**

The Chinese VR industry is currently becoming increasingly mature. According to data from 2012 to 2016, hardware device financing occupied 62.6% of the Chinese VR technology market, content production financing occupied 24.6% and distribution financing occupied 12.8% (Cai, 2017). As for the Chinese VR user market, the research suggests that more than 70% of users are heavy users who use VR devices every day. Furthermore, there are 2.86 billion potential VR users in the 15 to 39-year-old demographic (Yuan and Yang, 2017).

According to the latest analysis report by the iResearch Consulting Group (2017), the VR market in China has shown a significant increase and by 2021, China is likely to be the biggest VR market in the world. The size of the industry is predicted to reach 720.2 billion Chinese Yuan in 2021, which would be a considerable increase from the 34.6 billion Chinese Yuan that the Chinese VR market was worth in 2019. In addition, the Chinese VR market aims to focus on content production, making this the greatest proportion of the market segment.

### **2.3.3 Society**

There are ever more VR technology users in China and VR has been applied to the game industry, film industry, offline VR experience halls, real estate development, tourism, medicine and medical training in China. Furthermore, there are many teams working to find applications for VR technology in other industries, especially since VR technology has gained a lot of supporters in Chinese society.

### **2.3.4 Technology**

China has been investing in research on VR since the previous century and there are a number of institutions engaged in research on VR technologies, such as Xi'an Virtual Reality Engineering Research Center, Zhongguancun International VR Institute and QingDao Research Center. The VR industry in China is gaining more and more traction and has a promising future in technology development. Although VR technology in China has not yet reached the development level of other countries and China does not have a VR-related company with a significant global influence in the VR industry, VR technology nonetheless has huge potential in China.

### **2.4 Summary**

This chapter explores the fundamentals of the realization of VR technology. It can be seen that VR technology has broad developmental prospects, especially in the field of medicine. Based on the successful cases of VR technology being applied in medicine and the acceptance of VR technology in China, the application potential of VR technology in the treatment of PTSD symptoms of breast cancer patients in China is worth studying.

## **Chapter 3: Breast Cancer and PTSD**

### **3.1 Breast Cancer and Treatment**

According to the definition from the National Cancer Institution (breast cancer, n.d.), breast cancer cells gather and grow in breast tissue. It is a heterogeneous disease that has become a major public health problem worldwide. A breast tumor is comprised of a phenotypically diverse population of recognized biological subtypes (Varey et al., 2006) and ductal carcinoma is the most common type of breast cancer. Both men and women can contract breast cancer, although breast cancer is rare in men. Causes of breast cancer include reproductive factors, genetic predisposition, alcohol intake etc. (Wild, Weiderpass and Stewart, 2020).

Currently, breast cancer can be treated by lumpectomy with radiotherapy (which is the most common primary breast cancer treatment), axillary lymph-node dissection treatment, radiotherapy, systemic hormone therapy, chemotherapy (including preoperative and combination chemotherapy), hormone therapy and dose-intensive and high-dose chemotherapy. Local breast cancers that do not exhibit symptoms of spread have a high likelihood of being fully cured by local or regional treatment. Hormonal therapy has become the first choice for patients suffering from limiting but non-life-threatening diseases (Gabriel and Hortobagyi, 1998).

### **3.2 Mental Health of Chinese Female Breast Cancer Patients**

In China, breast cancer is one of the main malignant tumors and the incidence of breast cancer is highest among both urban and non-urban women. Furthermore, the incidence rate of breast cancer has demonstrated an increasing trend in the last 20 years since 2000. In 2011, there were about 249,000 new female cases of breast cancer in China, which was higher than all other types of female cancer. Moreover, the incidence rate differs between women from urban and rural areas. In 2011, there were 158,000 new cases in urban areas and 91,000 in rural areas, thus, urban areas accounted for 63.59% of cases, compared to 36.41% from rural areas. This indicates that urban women show a higher incidence of breast cancer than rural women. In 2011, the rate of breast cancer in China as a whole was 0.03768%, compared to a global rate of 0.02665%. Patients are discouraged from routine breast cancer check-ups and consultations

due to a less Western lifestyle , for example in terms of diet (Green and Raina, 2008) and cultural beliefs and social constraints (Mo, 1992). Hence, Chinese citizens clearly suffer from a higher rate of breast cancer than the global average (Zhao et al., 2019).

Fortunately, due to the improvements in medicine in China, radical mastectomy is now seldom used as a breast cancer treatment (Gabriel and Hortobagyi, 1998). This is a treatment that removes the primary tumor by removing part of the patient's breast; although it has a certain success rate it also causes partial loss of the breast (Maughan, Lutterbie and Ham, 2010). Currently, a comprehensive treatment plan for breast cancer generally focuses on surgery with assistance from radiotherapy, chemotherapy, endocrine therapy and targeted therapy. These treatments can minimize the physical and mental suffering of patients (Ferrell et al, 1996). In addition, some treatments are focused on aesthetic appearance and maintaining the ability to breastfeed. This can, to some extent, relieve the pressure on female patients following treatment, especially for young women suffering from psychological stress.

Although the physiological pain of breast cancer patients can be alleviated, current treatments are generally insufficient to allow patients to entirely ignore the pain and live a normal life. Surgery still brings with its significant suffering and aftereffects. The side effects of radiotherapy, chemotherapy, other adjuvant treatments, and economic pressures (for example, patients may require treatment for more than a year and the costs of breast reconstruction) remain serious problems facing patients and may affect patients' mental health. In addition, most breast cancer patients will pay special attention to the support and care of their relatives, spouses, colleagues, friends, etc., and the people around the patients will also indirectly affect their psychological state. The main characteristics of the mental health issues of breast cancer patients can be divided into the following aspects: depression and anxiety, an inferiority complex about their appearance or physical functions, and valuing quality of life and their careers.

With developments in psychology, increasing attention is being paid to the influence of mental health on tumor diagnosis, treatment and post-treatment. Psychotherapy has become an important aspect of tumor therapy (Chen and Zheng, 2015). However, in the treatment of breast cancer, women's mental health is still not being given sufficient attention. The loss of some breast tissue or even the whole breast as a result of treatment is still inevitable. On the one hand, breasts are among women's major physical features and have a special significance because

they symbolize beauty and child-bearing. As a result of these connotations, female breast cancer patients can experience more serious and specific psychological problems than other cancer patients. On the other hand, breast cancer has the highest survival rate of all cancers. Patients' survival rates after treatment in one, three, five and more than five years are 90.5%, 80.0%, 73.0% and 72.7% respectively (Zhao et al., 2019). With such a high survival rate, although female patients are likely to recover physically, they may nonetheless suffer from psychological problems after a long period of treatment, negatively affecting life after treatment.

### **3.3 PTSD Symptoms in Breast Cancer Patients**

#### **3.3.1 PTSD Symptoms**

PTSD is contracted in response to an experience of helplessness, horror or fear after undergoing a natural disaster or man-made accident (Yehuda, 2002), or as a result of a threatening or disastrous physical or mental trauma caused by war, a serious traffic accident, natural disaster, terrorist incident etc. (Chen, Zhang and Cheng, 2018). People suffering from this psychosocial dysfunction exhibit symptoms such as an increase in alertness and the startle response, a loss of concentration, irritability, anxiety and physical discomfort. All of these symptoms have a certain negative impact not only on sufferers' personal and social interactions but also on their family's life and mental and psychological health (Tian, 2016).

However, not every victim of a traumatic event will contract PTSD; different clusters demonstrate different incidences of PTSD. Usually, 8% to 15% of normal people who experience a traumatic event contract PTSD, although the incidence rate among women is double that of men. The reason behind this is that women are more likely to suffer from sexual assault and other types of violence resulting in physical injuries (Cook et al., 2014).

In clinical research, the main characteristics of PTSD symptoms can be grouped into three categories: traumatic re-experiencing symptoms, avoidance or numbness symptoms, and hyperarousal symptoms (Cook et al., 2014). Often, clusters of these three types of persistent symptoms occur together, making the experience of PTSD more unbearable for the patient (Yehuda, 2002). These categories of symptoms are now examined in more detail.



### 1) Traumatic Re-experiencing

Traumatic re-experiencing is a symptom that refers to patients undergoing the traumatic experience that triggered their PTSD by means of intrusive memories, dreams, flashbacks, or exposure to similar traumatic events, even if those events do not feature any triggers or related objects. This feeling of trauma can arise out of nowhere and patients feel as though they are really in the traumatic situation. Thus, re-experiencing a traumatic experience is almost the same as the traumatic event that they previously experienced. A further clinical symptom related to this is adverse mental or psychological reactions after facing a similar traumatic event or traumatic trigger. Patients usually experience symptoms such as feeling fear, depression, an increase in heart rate and respiratory rate and sweating. When experiencing these symptoms, patients are unable to control the timing and scale of their adverse reactions, resulting in inconvenience, if not pain.

### 2) Avoidance

Avoidance is the main symptom of PTSD. This refers to patients trying to avoid recalling or thinking of the person, object or event that caused the traumatic incident and may be extended to related areas, people or objects. Avoidance limits patients' emotional expression and can result in a sense of numbness. Patients experience this symptom usually try to avoid connections between people and their interactions may also be characterized by a sense of numbness. These kinds of avoidance behaviors can help patients to temporarily release the pain brought about by traumatic events. However, if a patient demonstrates avoidance behaviors for a long time, they may begin to suffer from communication disorders when trying to build connections or relationships with others. Additionally, such patients may experience difficulties when they are trying to fit into society.

### 3) Hyperarousal

Patients who experience hyperarousal often face difficulties falling asleep or easily wake up after falling asleep. This symptom is further characterized by an increased heart rate, restlessness, poor concentration, muscular tension and increased alertness in the early stages of the manifestation of PTSD symptoms. Increased alertness does help patients get used to the trauma following a traumatic event. However, as patients attempt to return to normal life, they may find it difficult to fit into normal society, with negative effects for mental health and quality of life. Some patients may even exhibit negative or violent behaviors such as self-harm or hurting others (McGovern et al., 2014).

### 3.3.2 PTSD Symptoms in Breast Cancer Patients

Cancer is a chronic disease that patients may suffer from for years. Thus, it often brings with it other stress-related diseases due to the long-term nature of treatment, including emotional fluctuations, uncertain prognosis, and side effects from the treatment, which themselves cause long-term suffering (Agnieszka and Kamilla, 2018).

Patients may suffer from stigmatization, the loss of limbs or other body parts, separation from family (Lehto, 2017), lower quality of life (Derogatis et al., 1983) and even psychiatric disorders (Gopalan, 2013). Furthermore, patients may experience symptoms similar to those exhibited by PTSD sufferers, such as pervasive anxiety, intrusive thoughts and avoidance behaviors (Michael, et al., 1998). Thus, not only the physical health but also the mental health of patients is an important aspect of cancer treatment and even life after treatment. If breast cancer patients suffer from more serious PTSD symptoms, they are likely to experience more extreme depression and low self-evaluation. Depression can bring about an ‘adversity growth’ mindset in patients, which can help patients to face the traumatic event, rather than avoiding it. When patients have a sufficient positive mindset when facing the traumatic event and use psychological resources properly, the negative emotions are transformed and their original cognitive evaluation system is stabilized (So et al., 2010).

PTSD is one of the most serious mental health problems suffered by breast cancer patients. However, none of the non-Asian research suggests that breast cancer is the direct cause of PTSD in female patients. A study by Michael et al. in 1998 on the existing literature in this area found that although breast cancer may not cause PTSD in patients, it can be a stressor causing patients to suffer from symptoms of PTSD. In addition, according to research by Arnaboldi (1998), the cancer experience can be considered to be a traumatic event and may cause PTSD symptoms. The sense that their lives are threatened, the severity of symptoms and the treatment itself may all trigger PTSD symptoms in cancer patients (Tedstone & Tarrier, 2003). According to a study by Kangas et al. (2002), the PTSD incidence of breast cancer patients is 5% to 10% in the early stages, which is lower than the standard incidence of PTSD.

However, according to the results of a study conducted by Chinese scholars Li et al. (2015), in 45 cases, patients gained a score of more than 41 (where 38 to 49 means certain levels of PTSD

symptoms) on the PTSD Checklist-Civilian Version (PCL-C) Scale. The incidence of PTSD among breast cancer patients is 21.4%, which is higher than the average incidence of PTSD symptoms in China, which is 1-14% (Zhang, 2009). These findings differ from those of other countries, possibly due to differences in the definitions of PTSD, research operability, dimension setting, research tools and calculation methods. For instance, in Kangas's research (2002), 10 evaluation indicators were used to measure the PTSD incidence of breast cancer patients, which may have caused the difference between the findings of the various studies.

In addition, the caregiver factor is often ignored in the research indicators. A study by Zhu et al. (2018) found that depression and pressure from caregivers may also be predictors of PTSD levels because PTSD can be measured indirectly through these two indicators. When patients exhibit slight PTSD symptoms, their caregivers are under less pressure and the patients demonstrate better mental and physical health and improved treatment outcomes. The system interaction model indicates that the stress experienced by one person in a relationship indirectly influences their spouse, while pressure from family members has a direct effect on the relationship between a husband and wife (Bodenmann, 2005). Caring, both physically and emotionally, for a breast cancer patient is stressful for their family members. The emotional concerns, responsibilities and difficulties that arise in caring for a patient suffering from PTSD may affect caregivers. This sense of stress may be passed on to the patient, causing negative effects for the patient's attitude toward their disease and themselves. This factor is usually ignored in the PTSD assessment of breast cancer patients. At the same time, due to the uniqueness of Chinese society and culture, women have low status and are associated with negative stereotypes such as being weak, powerless, and sexually insatiable. Furthermore, cancer is usually connected with death, which is considered to be an ominous topic in daily life, so some women believe that it is wrong and shameful to talk about breast cancer with their friends or family. Consequently, breast cancer checks are uncommon in annual physical examinations and when women feel discomfort in their breasts, they often ignore it because they feel too ashamed to consult a doctor (Topley, 1975). When these factors are taken into consideration, it is found that Chinese society and culture may increase the likelihood of female breast cancer patients suffering from PTSD (Li et al., 2015). Furthermore, the insufficient research on the incidence rate of PTSD among female breast cancer patients may be a significant factor. Nonetheless, there is clearly a phenomenon of PTSD arising in female patients due to breast cancer.

### **3.4 Traditional Therapy for Breast Cancer Patients' PTSD Symptoms**

PTSD is recognized as one of the most typical common mental and psychological disorders and arises after experiencing a significantly threatening or disastrous traumatic event. The trigger could be natural disasters, traffic accidents, criminal violence, abuse or war, among others. Moreover, PTSD sufferers may have suffered from such traumatic events directly, for instance as a victim of violence, or indirectly, by witnessing an event that occurred to other people (Yuan et al., 2018). According to the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) published by the American Psychiatric Society in 2013, the core symptoms of PTSD fall into four categories:

- 1) Having one or more intrusive experience related to a traumatic event after the traumatic event has occurred;
- 2) Continuous avoidance of traumatic events;
- 3) Negative change to a patient's cognitive and mental functions relating to a traumatic event;
- 4) Increased trauma-related alertness and reactivity.

According to research conducted by McGregor and his colleagues (2015), cognitive-behavioral stress management, as an aspect of cognitive behavior therapy (CBT), is a recognized and efficient therapy for treating PTSD in breast cancer patients. There is only initial evidence demonstrating that cognitive-behavioral stress management could be used in the treatment of PTSD in breast cancer patients. However, the research object and methods are different, so the question of whether cognitive-behavioral stress management can be used to treat PTSD in breast cancer patients deserves further research. This chapter discusses the potential and shortcomings of using CBT, in addition to investigating traditional treatments in depth.

#### **3.4.1 Development of Cognitive Behavioral Prevention Treatment**

As a result of surgery, radiotherapy, chemotherapy, hormones and the cancer itself, breast cancer patients may exhibit cognitive dysfunction caused by the individual control of the brain structure. Due to the cognitive dysfunction, and specifically the decrease in cognitive function, some patients suffer from memory decline, inattention, recall difficulties, an inability to express their feelings and even problems communicating in conversations.

CBT is a therapy that focuses on helping patients develop self-control in their thinking, ideas, attitudes, and skills (Gaudiano, 2008). Researchers have already proven that it can be used in reducing PTSD symptoms (McLay, 2010). With further research into CBT, this method has been applied to improving cancer patients' quality of life (Hermelink et al., 2017). CBT is composed of two parts: cognitive therapy and behavioral therapy. The theoretical basis is that the cognition of an individual can control their emotions and behaviors; emotion and behavior, meanwhile, can also affect an individual's cognition. Cognitive-behavioral prevention corrects a patient's poor lifestyle and negative cognition, in order to reduce cancer patients' depression and anxiety by reducing their symptoms of pain, nausea and fatigue (Perry et al., 2017).

According to related literature, CBT can be used to treat PTSD. In the next section, the influence of cognitive behavior on breast cancer patients is examined.

### **3.4.2 CBT and PTSD for Breast Cancer Patients**

The main prevention treatments for PTSD are considered to be psychotherapy, medicine therapy and social support. Currently, there is considerable international research indicating that CBT is the most effective means of treatment (Bisson et al., 2013). CBT is based on Ehlers and Clark's (1999) cognitive model and encourages patients to focus on traumatic memories, helping them to recognize and prevent negative cognition and ways of thinking, with the aim of acknowledging and correcting unhelpful behaviors. The advantages of employing CBT in PTSD treatment are that it has a short prevention period and clear and strong targets (Ehlers and Clark, 2000). Studies show that CBT can be useful in decreasing the levels of depression and anxiety experienced by PTSD patients. From a psychological perspective, inwardly reliving a traumatic event can be painful and patients may feel conflicted deep inside their conscious while they are struggling about whether should they merge the traumatic event with their original beliefs or not. Study theory considers that the generation of PTSD is a kind of reflection of fear. When individuals try to avoid traumatic memories to reduce their fear and anxiety, their avoidance behaviors are strengthened. In this way, the fear of the cognitive structural framework is activated and a fear response is created, this in turn activates the avoidance structural framework, resulting in an avoidance response.

In *Clinical Practice Guidelines for the Treatment of PTSD* published by the American Psychological Association in 2017, CBT is considered to be a useful treatment for PTSD. In

terms of applying it to the treatment of PTSD in breast cancer patients, in the early stages of treatment, motivation interviews were employed to fully understand the cognitive deficit of patients in the prevention process of developing a good relationship and trust between doctors and patients. The next step was to correct negative cognition by arranging disease-related healthy knowledge lectures for the CBT experiment group, for instance on how the disease is contracted, to inform patients about the disease, and how to face life after treatment, etc. according to patients' negative cognition expressed in the late intervention. During the treatment, female breast cancer patients experienced self-image disorder because of the side effects brought on by treatments such as surgery and chemotherapy. In addition, patients may have difficulty fitting into their family and social life. However, through the convenience of WeChat groups (a popular online social network software in China that is usually used as a communication tool), patients may be more willing to open their hearts and find solutions to their problems through self-reflection (Wang, 2016). They face life with a more positive attitude and better integrate into family life (Hasson-Ohayon et al., 2015). Post-treatment physical function exercise in the early stage has been proven to be an effective way to help individuals recover their cognition, reduce their pain and improve the quality of sleep.

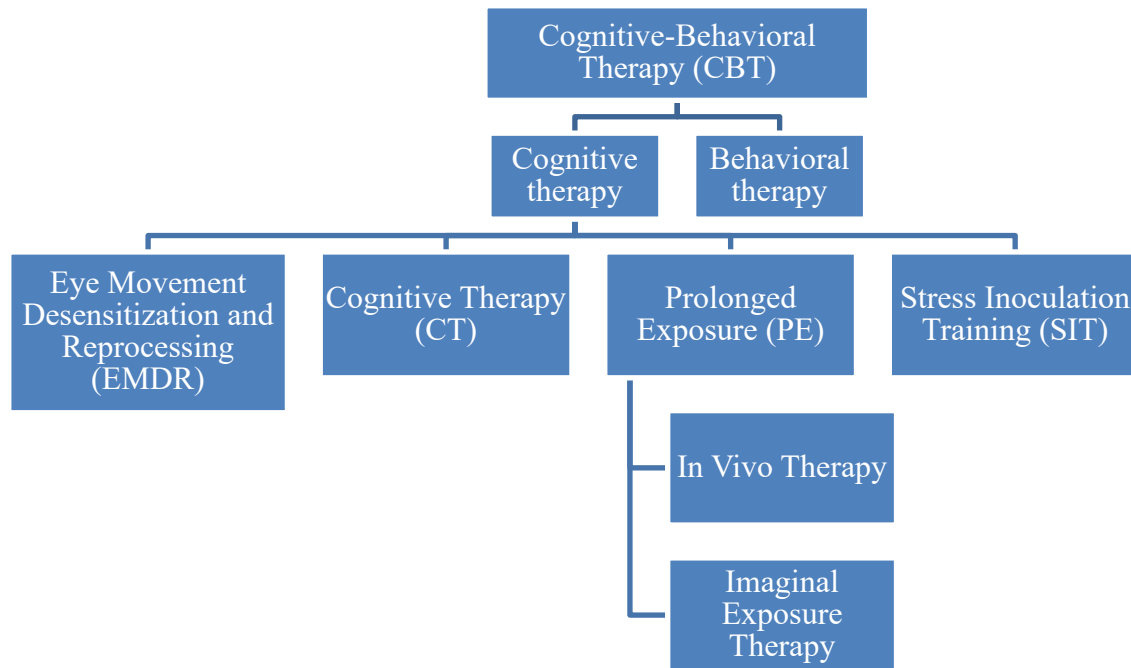


*Figure 3.1 CBT in breast cancer patients' PTSD treatment*

### **3.4.3 Disadvantages of Cognitive Behavior Prevention Treatment**

Usually, the most efficient form of PTSD psychotherapy is CBT, which includes prolonged exposure, stress inoculation training, cognitive therapy and eye movement desensitization and reprocessing (EMDR) (Chen and Zhu, 2018). At the moment, exposure treatment is the most common PTSD treatment plan. The point of exposure treatment is to create a safe environment in which patients can trigger their traumatic memories and patients' fear levels can be controlled and managed through the use of relaxing technology and the guidance of the therapist. It is a treatment that brings patients' traumatic memories or imagination to the surface, allowing the patients to improve their confidence and reduce their avoidance behaviors (Xiao

and Li, 2017). Usually, an exposure therapy plan that aims to treat PTSD can be considered as one of two types: in vivo therapy and imaginal exposure therapy (Nelson, 2013). In in vivo therapy, patients are asked to stay in a trauma-related real environment and experience a real trauma-related trigger at an acceptable level. Imaginal exposure therapy, on the other hand, requires patients to experience a similar trigger by imagining the traumatic environment themselves.



*Figure 3.2 Types of CBT treatment*

However, there are disadvantages to both in vivo therapy and imaginal exposure therapy in practice, which may reduce the efficiency of the treatments. For example, with respect to in vivo therapy, Rothbaum (1999) found that in treating PTSD in soldiers of the Vietnam War, the sound of helicopters flying could be the most triggering sound for veterans, causing traumatic reactions including anxiety and fear. However, it is unrealistic to use a real helicopter to create an exposure environment for patients because of budget constraints and the challenge of controlling emotional intensity and levels of exposure to the trauma-related event. With respect to imaginal exposure treatment, patients' willingness to imagine an event or environment and the content of their imagination are crucial factors that directly affect treatment outcomes.

### 3.5 Summary

Traditional methods of treating the symptoms of PTSD in breast cancer patients are to some extent successful, but at the moment, they are not the most efficient means of treating patients. Because of social development, better treatment plans can be constructed due to technological improvements and increases in income, which enable patients to hire better doctors and obtain better medicine, etc. According to the Canadian Cancer Society (1988), one in 11 female patients have to undergo treatment for the rest of their lives, which can be a huge burden. Patients do not have to be treated by traditional methods; better, cheaper, more efficient and less painful treatment plans exist, for which VR technology could be key. Of these, prolonged exposure therapy may be the most efficient way of treating PTSD symptoms. In the next chapter, the potential for using VR technology in exposure therapy to treat PTSD in breast cancer patients will be discussed.



## **Chapter 4: VR Technology for Treating PTSD in Breast Cancer Patients**

Through discussion and analysis, it can be concluded that CBT is effective in the treatment of PTSD symptoms in breast cancer patients. In CBT, prolonged exposure is the most commonly used method of treatment, however, it is associated with high costs and poor curative outcomes. In order to solve these problems, Rothbaum (1999) for the first-time applied VR technology to the prevention and treatment of PTSD and achieved some success. This study has subsequently inspired other scholars to examine the possibility of applying VR technology to the treatment of PTSD.

There is an increasing number of applications for VR technology in the treatment of PTSD, for example, the virtual Iraq and Afghanistan treatment conducted by the University of South California and experimentation in the use of VR technology in Fallujah Camp Mental Health Clinic (McLay, 2010). However, due to the differences in disease types and patients' gender and cultural background, the question of whether VR technology can be successfully applied to the treatment of PTSD symptoms caused by breast cancer in Chinese women requires further study. Therefore, in this chapter, the application potential of VR technology in the treatment of PTSD symptoms in women suffering from breast cancer in China is explored, with specific reference to the use of VRET and the potential of the prolonged exposure treatment method.

### **4.1 Applying Virtual Reality in PTSD Treatment**

With the continuous improvement in VR systems, the emphasis of a particular VR system varies according to the different applications and usage. Currently, there are two different ways of presenting VR scenes. Firstly, the classic means of presentation uses three-dimensional effects to emphasize the concreteness and authenticity of the scene. Rothbaum (1999) was the first person to use the 'Emagin Z800 3D visor', which was the world's first head-mounted display that supported 3D functions. In recent years, the US military has helped Vietnamese and Afghani soldiers develop a computer-aided rehabilitation environment to support their recovery from mental health problems. This technology usually includes a treadmill, a curved panoramic image and an array infrared camera, which enable the users to interact with a virtual scene. These factors mean that the system offers a strong sense of immersion (Highland, Kruger and Roy, 2015). The second way in which VR scenes can be presented is to stimulate a user's

emotional response through custom symbols and personalization without emphasizing the fidelity of the scene presentation itself. For example, the 'Emma's World' system used by Botella (2015) and others enables the user to interact with virtual objects, such as images, videos and music, related to a traumatic event. At the same time, virtual scenes such as deserts, forests and villages, and virtual weather such as rain, snow and storms can be programmed to change with the patient's emotions.

The learning mechanics to game mechanics (LM-GM) used by Menelas et al. (2018) is another new system that has recently been released. It divides the game into different levels based on the desired level of exposure and includes traumatic scenes at each level of the game. Once a user completes a level and moves on to the next, they gain certain responses and rewards, which engage and encourage them to interact more with the virtual environment. The more the user interacts with the virtual scene, the higher the level of exposure they will be presented with, which to some extent improves the sense of immersion.

#### **4.2 Virtual Reality Exposure Therapy**

VRET is a method for treating patients through the application of VR technology. The patient is exposed to virtual scenes for treatment purposes while following a storyline and virtual world narrative that encourage playfulness. VRET is an aspect of CBT treatment, nonetheless, the treatment process and persistence of the two are different.

Based on current research, VRET is similar to the traditional prolonged exposure treatment method, which comprises three stages: psychological education (in the first three weeks), exposure therapy and relapse prevention therapy (in the final week). The patient undergoes treatment once or twice a week. The treatment period usually lasts between 8 and 12 weeks depending on the patients' symptoms, but can last for as little as three weeks or up to 20 weeks. In the psychological education stage of treatment, a psychotherapist introduces the treatment pathogenesis, process, setting and precautions to the patient and assesses the severity of their symptoms through a questionnaire assessment and structured interview. The psychotherapist uses the assessment to rank the triggers according to the anxiety level that they provoke and subsequently establishes an appropriate exposure level for the VR environment together with the patient. In the exposure therapy stage, the patient undergoes exposure treatment using VR technology for a specific period, usually 90 minutes. At different stages of treatment, the VR

system offers different features and the traumatic event-related exposure level increases as the patient undergoes more treatment sessions. Some researchers give patients physical ‘homework’ based on the exposure level of two treatments (McLay et al., 2017). Normally, to avoid excessively raising or lowering the emotional level of the patient during the treatment sessions, the therapist invites the patient to give regular feedback while experiencing the VR scene. In addition, the psychotherapist allows the patient to take the anxiety level assessment during one of their treatment sessions in a specific time period and adjusts the progress of the exposure levels based on this. Relapse prevention therapy is the final stage of treatment. At this stage, the patient’s main task is to review and conclude the achievements of their treatment and discuss solutions for treating any PTSD-related symptom, should they arise again in future.



*Figure 4.1 Three stages of PTSD treatment*

### **4.3 VRET in PTSD treatment**

There have been a number of experiments that have applied VRET to PTSD treatment, most of which have achieved a certain degree of success. For example, Giotakos, Tsirgogianni, and Tarnanas (2007) applied VRET in an attempt to reduce elderly adults’ fear of falling for balance rehabilitation, with most of the subjects demonstrating a reduction in their symptoms. The researchers developed a virtual ‘shopping list’ and the gameplay consists of purchasing the products on the shopping list. To complete the task, the user has to walk in different conditions, such as freezing winter weather, on a slippery wet floor or on an inclined road. These conditions are designed to reflect common scenes that may cause the elderly to experience problems with balance or falls. Another experiment supported by the New York State Center for Engineering Design and Industrial Innovation and the University at Buffalo designed a real-time driving scene for PTSD treatment following road traffic accidents. In the treatment, the patient is asked to be the driver or passenger while the instruction therapist stays near the patient to help them complete the exposure therapy. The therapist observes the patient’s behaviors and responses and records these as an indicator for adjusting to the next treatment level. When the patient

completes the 10-session treatment, their PTSD symptoms have been significantly reduced. Furthermore, patients reported gaining a high level of satisfaction from the use of VRET (Gayle Beck et al., 2007). By creating a virtual scene related to the patient's traumatic event, rather than through traditional imagination or an oral description, the patient can be treated in an effective manner. Moreover, due to the high satisfaction, patients may be more willing to undergo treatment, which contributes to cultivating a positive mindset towards the treatment process. However, because VRET is a new and developing treatment, how it can be improved for PTSD treatment deserves further research.

#### **4.4 Comparison of VRET and Other Treatments for PTSD**

As a treatment that integrates cutting-edge technology, researchers have high expectations for VRET. The current literature concludes that most of the research indicates that VRET helps relieve patients' PTSD symptoms. However, there is insufficient research into the more obvious advantages of VRET over traditional exposure therapy.

Gonçalves et al. published the first summary of VRET as applied to PTSD treatment in 2012 (Botella et al., 2015). The researchers filter ten more CBT-related summaries that had been previously published in May 2011 and compare them with VRET based on the PTSD diagnosis standards published by DSM-5. They found that there are seven summaries that could be used to prove the significant difference between the VRET treatment group and the control group. However, the VRET treatment group did not demonstrate any obvious difference compared with other treatment groups. Botella et al. (Gonçalves et al., 2012) compared six studies of VRET (excluding the four literature reviews mentioned by Gonçalves et al.) and other PTSD treatment plans (including traditional exposure therapy, prolonged exposure and eye movement desensitization reprocessing). Moreover, the research object included veterans, active-duty soldiers and patients whose PTSD was caused by various kinds of terrorist attack. This study proved that VRET is effective in treating PTSD symptoms, however, none of the research mentions a significant difference between the VRET group and other treatment groups. After 2014, Reger (2016) examined the treatment results for prolonged exposure and VRET in active-duty soldiers. The results show that patients' PTSD symptoms had been reduced in both treatment groups, however, there was no significant difference and in the follow-up research three and six months later, patients in the prolonged exposure group had lesser PTSD symptom levels than those in the VRET group. McLay et al. (2017) conducted the same research, coming

to the same conclusion; VRET does not have any significant treatment effect. In addition, through DiMauro's analysis (McLay et al., 2017), exposure therapy is more useful than VRET in reducing the recurrence of PTSD symptoms.

In summary, the current research cannot prove that VRET has better treatment results than other treatments. Some studies, in fact, have found that VRET has worse treatment outcomes, however, it remains a treatment worthy of further study..

## **4.5 Advantages of VRET**

Thus far, no studies have proven that VRET is more effective than other treatments because, as a new and developing treatment, studies on VRET are generally smaller than those on other treatments. Besides, studying VRET requires considerable funding for system development, purchasing VR equipment, recruiting VR technicians etc. However, the attention that VRET has attracted in just 20 years indicates that it has a certain attraction to researchers and operators. By examining the applications and evaluations of VRET in the existing literature, four advantages of VRET have been identified: reality, practicality, customization and privacy. These are examined in detail below.

### **4.5.1 Reality**

VR technology can give the user a sense of immersion during the exposure experience. This overcomes problems such as the patient's lack of imagination or refusal to engage in imagining a situation. It provides the user with a more realistic exposure environment, helping them to experience a stronger sense of empathy and have a better immersive experience in the virtual environment (Mishkind et al., 2017). From the perspective of the psychotherapist, using VR technology to replace the imagination enables the exposure environment to be more specific and overcomes the ambiguity of the exposure level and difficulties with assessment when patients use their imagination.

### **4.5.1 Reality**

Many traumatic events could not be presented or repeated accurately in the virtual environment. For example, natural disasters are one of the triggers of PTSD, however, patients cannot have an exposure experience for these kinds of traumatic events in reality. VRET provides these patients with a safe and practical option (Rizzo et al., 2015). Furthermore, VRET can be

conducted in a laboratory setting, which provides convenience for the medical experiment and saves energy.

#### **4.5.3 Customization**

VR technology can be set to display different images based on the individual patient's situation and sensitivities. Therefore, using VRET provides better control over the quantity, level and scene setting of influential factors and the means of interaction, based on the background of the individual patient, thus creating a customized exposure environment and bringing better treatment outcomes.

#### **4.5.4 Privacy**

In contrast to real exposure, VRET-based treatment sessions can be conducted in psychotherapists' offices or other private environments, which reduces the possibility of coming into contact with others and provides a more private environment for treatment.

### **4.6 Potential of VRET in Treating Breast Cancer Patients' PTSD Symptoms**

Based on the advantages discussed above, it could be considered that VRET has a significant effect in PTSD treatment. While VRET does not demonstrate any differences when compared with traditional exposure therapy, it has certain advantages linked to the use of VR technologies. The specificity of breast cancer patients' PTSD symptoms should be taken into consideration, given the gender of the patients, cultural differences and the fact that the traumatic events that they have undergone differ considerably from those experienced by other cancer patients. Furthermore, there is no existing research that focuses on applying VRET to the treatment of PTSD in breast cancer patients. Therefore, for this paper, certain assumptions are made based on related research and studies. In this section, the differences between PTSD in breast cancer patients and the standard presentation of PTSD are compared and the potential of VRET in treating PTSD symptoms in breast cancer patients is studied.

According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) published by the American Psychiatric Association, there are three categories of PTSD symptoms: re-experiencing, avoidance or numbness and increased alertness. Based on the DSM-5 screening criteria, the statistical analysis conducted by Zhang (2019) shows that the PTSD score illustrates obvious connections between each cluster of symptoms. Avoidance or numbness

symptoms have the highest score in breast cancer patients (84.3%), followed by increased alertness (78.9%), and re-experiencing (74.8%). These percentages show that most breast cancer patients have suffered from PTSD symptoms. The re-experiencing, avoidance/numbness, and high alertness scores are  $10.045 \pm 3.505$ ,  $13.864 \pm 4.711$ , and  $8.609 \pm 3.812$  respectively. The average score of breast cancer patients' PTSD symptoms is  $32.518 \pm 9.603$  and a score of 38 or over means the symptom is positive. Based on these data, it can be concluded that most breast cancer patients suffer from PTSD symptoms, however, the severity of most of the PTSD symptoms would not cause the PTSD. Nonetheless, the breast cancer could still cause the PTSD (O'Connor, 2011).

Avoidance/numbness symptoms are different from other traumatic symptoms in breast cancer patients. Through the study of videography, pathology, and clinical tests, the diagnosis of cancer itself is a trigger that may cause avoidance symptoms. The loss of secondary sexual characteristics during treatment and surgery causes patients to feel as though they are incomplete. The traumatic circle of a sense of incompleteness, pain from the disease, and repeated check-ups and treatment means that patients have to continually face the truth about their disease and are unable to forget about their cancer. Avoidance is an instinctive protection mechanism, but ongoing treatment means patients keep experiencing the same traumatic events and are unable to avoid them, resulting in greater psychological stress and further emotional problems. The sense of numbness reflects how patients feel about their disease. All of these factors may contribute to repeatedly triggering re-experience symptoms, which has a negative effect on patients' mental and emotional health. In addition, increased alertness is common among breast cancer patients. Furthermore, hair loss, pain, fatigue and other adverse reactions during radiotherapy and chemotherapy treatments cause a high state of nervousness and alertness in patients when they sense minor reactions in their body functions (Zhu, 2019).

All in all, breast cancer patients' PTSD symptoms differ slightly from those experienced by normal PTSD sufferers. Nonetheless, according to the research, breast cancer patients' PTSD symptoms meet the PTSD symptom criteria. Based on what has previously been discussed in this paper, VRET is effective in treating PTSD, so it is possible to use VRET to treat PTSD in breast cancer patients.

## **4.7 Advice for Using VRET in Breast Cancer Patients' PTSD Treatment**

Oyama and Waka (1997) studied the use of VR technology in medical applications and development for cancer diagnosis and treatment, finding that the three basic factors that may influence a VR system in medical usage are human, system and application factors. The human factor is one of the most important, and reflects the fact that the subject and essence of VR is to guide people's awareness. This means that when a VR system is designed, the foundation should be the human factor, in this context, the female breast cancer patient. The mental illness suffered by breast cancer patients can be characterized by the following features: depression and anxiety, concern or inferiority regarding appearance or physical functionality, the way in which they value their quality of life and their efficiency in the workplace. Although there are no existing studies on the use of VRET in the treatment of PTSD in breast cancer patients, based on the concept of treating PTSD and the application of VRET, the researcher can make a number of recommendations. These are discussed in detail below.

### **4.7.1 VRET Emphasis**

There are three stages at which breast cancer patients may contract PTSD: at diagnosis, during treatment and after treatment. As a result, the VRET treatment should have a different focus based on the stage at which the breast cancer patient is at.

When patients are diagnosed with breast cancer, anxiety and the fear of disease are the main triggers of PTSD. Patients may worry about their future, their family, their career etc. According to Kübler-Ross (1969), at this stage, patients are likely to have two major preoccupations, denying the diagnosis or fear of the cancer, which are both key to treating and preventing PTSD symptoms. During the treatment, it is important to develop a strong and trusting relationship between doctor and patient. The uncertainty and repeated treatment sessions are the traumatic triggers that may provoke PTSD. Thus, it is important to ensure that the patient has trust in the treatment and understands that the treatment process is essential. After the cancer treatment, the emphasis of the treatment for PTSD depends on how successful their cancer treatment was. If the patient has fully recovered, then they may trust the psychologist in the PTSD treatment (Enache, 2012). If the patient experienced side effects or negative outcomes during the cancer treatment, this may have a negative effect on the PTSD



treatment (Kovacs et al., 1981). Although patients may undergo breast reconstruction surgery, it may take them a long time to get used to it (Al-Ghazal et al., 2000).

According to a Korean study, the symptoms of anxiety and depression experienced by breast cancer patients are more likely to stem from an inferiority complex (Tae, Heitkemper and Kim, 2011). In addition, a Spanish study shows that low self-esteem has a negative effect on patients' social function (Manos, 2015), relationships, quality of life, and careers. According to research by Manos et al. (2005), social support can also help to alleviate the PTSD symptoms of breast cancer patients. Furthermore, research by Ebright and Lyon (2002) indicates that social support, self-esteem and religious beliefs help female patients to deal with their breast cancer and thus decrease or prevent the development of PTSD symptoms.

However, when the cultural context of China is taken into account, improvement in self-esteem are also important in VRET. Confucianism plays an important role in traditional Chinese culture, encouraging people to sacrifice themselves for the good of society. This tradition emphasises the importance of overcoming individualism and personal desires, which means that when people encounter something that dissatisfies them, they should accept it rather than complaining (Wang and Ollendick, 2001). Moreover, in traditional Chinese culture, cancer and the body are taboos that should not be mentioned in conversation. Breast cancer is consequently a particularly taboo subject (Topley, 1975). In this context, women are discouraged from undergoing breast cancer checks, consulting doctors, or acquiring any knowledge relating to breast cancer, which increases the risk of them contracting breast cancer. Furthermore, some female patients may experience breast loss as a result of the treatment and subsequently feel incomplete or imperfect. However, when they experience these feelings, they may not be comfortable confiding in anyone because of the culture taboo that suggests that is impolite to talk about the body (Holmqvist and Frisén, 2010). These kinds of feeling are also influenced by the cultural environment of society (Jung and Lee, 2006), so social support can reduce the sense of incompleteness or imperfection. Based on the Chinese context, VRET should focus on improving female patients' self-esteem and ensuring that they receive and feel the benefit of social support systems.

#### **4.7.2 Scene and Narrative Creation**

Following breast cancer treatment, female patients may find it easier to integrate into social circles, for instance among their family or friends. However, their career and marital relationships may prove to be more complicated. Moreover, patients' breasts may have been fully or partially removed in surgery, resulting in patients experiencing a sense of loss of femininity, depression, shame and low self-esteem. To reduce the symptoms of PTSD, an improvement in self-esteem and appreciation of social support are essential.

The loss of a breast is the main reason for low self-esteem, due to its psychological and aesthetic significance. (Popovic, Slamic and Cosic, 2020) In this situation, the VR creator can use 3D technology to rebuild an image of what the patient will look like after surgery when they have lost their breast, or after undergoing breast reconstruction surgery, and let the patient interact with their virtual selves. The virtual world could include places that the patient is familiar with, in order to build and strengthen the sense of immersion. This would help the patient to gradually develop a sense of acceptance of their self-image after the surgery, rather than seeing the loss of their body part suddenly after the operation, which could reduce the traumatic nature of this event. With respect to social support, the VR creator can build a virtual world that exactly resembles the patient's life in order to allow the patient to model the future life and become accustomed to it. In the virtual world, the scene narrative should imitate the patient's daily life as closely as possible. If they feel comfortable interacting in the virtual world and gain a positive response from the virtual society, the patient will be more likely to sense support from their real community (Von Ah, Kang and Carpenter, 2007).

Additionally, the VR creator can develop a virtual interactive operation that allows the patient to undergo breast cancer surgery and treatment as an outsider, in order to fully understand the whole treatment process and reduce their sense of anxiety.

#### **4.8 Outlook for VR Technology in Treating PTSD in Breast Cancer Patients**

As an emerging treatment approach, VR technology is widely used in phobia and anxiety treatment but less so in PTSD cluster prevention; the application of VRET in PTSD treatment is still at an exploratory stage (Rizzo et al., 2015), especially with respect to breast cancer patients. There is no research or treatment that applies VR technology in treating PTSD in

breast cancer patients. Furthermore, there are a number of problems that must be solved when studying the application of VR technology in this area. Based on existing research, the outlook of applying VRET in the treatment of PTSD in breast cancer patients is described below.

Firstly, a focus on rigorous and scientific research methods for studies on VR technology is critical. The sample size, that is to say, the number of breast cancer patients studied, should be increased. Once the sample size is sufficiently large, the results of the research can be used to compare VRET to traditional exposure therapy, thus making such a comparison more reliable. DiMauro (2014) believes that a comparative study of VRET and traditional exposure therapy requires more scientific assessment criteria.

In addition, follow-up studies should focus on randomization in the standard experiment and prevention result follow-up research. With greater research on the comparative study of VRET and traditional exposure therapy, researchers can focus on summarizing the operation system, model, intervention course etc. used in VRET studies. Such summarized conclusions would prove useful to other studies on the efficiency of VRET in PTSD intervention treatment, hence normalizing this treatment process.

Finally, the sense of immersion must be optimized. The efficiency of human-machine interaction and the comfort of operation and usage are essential for improving the sense of immersion and subsequently treatment outcomes. The degree to which the exposure environment provided by VR technology feels real is connected to the treatment effect. There is some existing research that shows that if VRET can also focus on improving multichannel sensory stimulation, such as smell or touch, rather than simply concentrating on vision and hearing, the treatment effect would be considerably improved (Taffou et al., 2013). In addition, if VRET could combine the advantages of 'Emma's World', for instance with respect to arousing emotions and gamified learning in exposure development, it would help to improve the effectiveness of VRET in PTSD treatment.

#### **4.9 Conclusion**

At present, there is no research to prove that VRET can be used in treating PTSD in breast cancer patients, nonetheless, the symptoms of PTSD in breast cancer patients are consistent with traditional PTSD symptoms. Some studies have proven that VRET can be used in treating

PTSD, with significant effects. Therefore, the preliminary hypothesis is that the application of VRET is feasible in the treatment of PTSD in breast cancer patients. Compared with other cancer patients, female breast cancer patients demonstrate different psychological problems due to gender, physical side effects and cultural reasons. If VRET technology can be improved based on these characteristics, the PTSD symptoms of breast cancer patients could be relieved. Furthermore, because the PTSD of breast cancer patients is often ignored in cancer treatment, if attention could be paid to the physical and mental health of these patients simultaneously, then their suffering would be reduced.

## Chapter 5: Conclusion

### 5.1 Conclusion

This research paper offers a hypothesis concerning the application of VR technology in the treatment of PTSD in breast cancer patients in China, and this hypothesis is theoretically valid. Inspired by a conversation with a breast cancer expert and the experience of the author's mother when suffering from breast cancer in China, the psychological state of the patient following the cancer diagnosis is important to both treatment and the patient themselves. However, this can easily be ignored by patients, doctors, patients' family etc., and deserves more consideration.

This research paper adopted literature research, case analysis and interdisciplinary research methods. Initially, it was found that the PTSD symptoms caused by breast cancer are rare and invalid in most Western countries, nonetheless, they are valid in China. Through comparing the PTSD symptoms caused by breast cancer and the main PTSD symptoms defined by the *Diagnostic and Statistical Manual of Disorders (DSM-5)*, those exhibited by breast cancer patients were found to almost match the standard definition. Furthermore, the conclusion that breast cancer could be a PTSD trigger has been internationally confirmed. Among PTSD treatments, CBT is recognized as one of the most effective. In particular, prolonged exposure is considered to be the most effective treatment approach when combined with VR technology. VR exposure treatment has already gained certain success in PTSD treatment. Although it has not been proven that VRET has a better therapeutic effect than traditional treatment, there is evidence to indicate that a better therapeutic experience can be provided through the application of VRET. With the unknown potential of VR technology, further experimentation and research are recommended in the following areas:

- 1) Is VRET the best treatment plan for PTSD in breast cancer patients?
- 2) How can VRET be improved for treating PTSD in breast cancer patients?
- 3) Which form of VR interaction method is the most effective in the treatment of PTSD in breast cancer patients?
- 4) How can VR technology be used for prevention or intervention for PTSD in breast cancer patients?

- 5) What influence does nationality or cultural background have on the outcomes of applying VRET in the treatment of PTSD in breast cancer patients?
- 6) How can the application of a VR-related technology in PTSD treatment be effectively evaluated?

## **5.2 Research Contribution**

There is little literature on the application of VR technology for the treatment and prevention of PTSD in breast cancer patients, therefore, this research paper could engage more researchers, doctors, VR creators etc. to explore the potential of using VR technology in the fields of medicine, psychology, prevention and intervention. The goal of this research paper was to explore the potential of using VR technology in treating PTSD in breast cancer patients in China, and it is hoped that this will inspire VR creators to focus on psychological treatment and psychologists to adopt VR technology into their treatment practices. The research paper has indicated the potential of using VRET for the treatment of PTSD in breast cancer patients as well as the disadvantages of VRET with the intention of encouraging more VR technicians to improve VRET and explore more applications of VR in psychological treatment. With respect to medicine, breast cancer patients' psychological health is frequently ignored, however, this research has emphasized the importance of considering breast cancer patients' psychological health in China, in addition to incorporating psychological assessment into cancer treatment.

## **5.3 Research Limitations**

Since VRET is a new and developing treatment method, there are few studies, experiments or cases that could be used as reference in this paper, hence there are some data deviations in each reference. Furthermore, as a hi-tech phenomenon, VR technology is still in the developmental phase and thus its application and potential are still being explored. The question of how to make the best use of VR technology and how VR technology could be effectively applied to PTSD treatment therefore require further exploration. The unknown potential limitations restrict further research into the use of VR technology for the treatment of PTSD in breast cancer patients. Due to the specificity of the research object, that is to say, breast cancer patients, their psychological states differ from those of other cancer patients, thus, there are only few cases, studies and materials that are appropriate. In addition, the researcher was not able to

conduct actual VRET experimentation on the effect on treating breast cancer patients' PTSD symptoms, therefore, further experiments are required to determine whether VRET should, in fact, be adopted for treatment in this area. Since there are no direct studies focusing on this area, all the research is based on indirect assumptions.

#### **5.4 Future Work**

In order to improve this study, the author will use VRET in the treatment of PTSD in breast cancer patients. These follow-up experiments will enable the author of this paper to make recommendations for the more effective treatment of PTSD using VRET, such as the most effective narratives for VR games or scenes, or the gameplay mechanism. With enough experimental results, the author will start to create a VR scene for the treatment of PTSD in breast cancer patients with customizations that allow psychologists to adapt a single VR scene for different cases.

In addition, because of the unknown potential of VR technology, the author will study and compare the efficiency of VR treatment for PTSD in breast cancer patients. The usage of VRET in other types of PTSD treatment will also be studied.

While studying VRET, the author will also pay attention to the mental health of breast cancer patients. Because social barriers and culture beliefs are contributing factors to the high incidence of breast cancer, the author will additionally create online lectures or lessons to encourage women to talk about breast cancer and teach them basic techniques for self-checking their breasts. For example, this could include immersive VR scenes introducing the process of breast cancer treatment to relieve patients' anxiety, interactive scenes to show patients what they would look like after reconstructive surgery, knowledge-based storytelling scenes for children to learn about breast cancer, and online and offline VR interactive games to raise awareness of caring for breast cancer patients and patients' psychological health.

In the future, the author will also try to create affordable VR tools for treatment in hospitals and clinics or even for personal use. Perhaps in the future, every patient could have their own VR equipment and enjoy therapy in their home when they feel stressed. With a more enjoyable treatment experience and affordable prices, patients could benefit from better treatment outcomes following therapy.

## Reference list

- Al-Ghazal, S., Sully, L., Fallowfield, L. and Blamey, R., 2000. The psychological impact of immediate rather than delayed breast reconstruction. *European Journal of Surgical Oncology (EJSO)*, 26(1), pp.17-19.
- Agarwal, G., Pradeep, P.V., Aggarwal, V., Yip, C.H. and Cheung, P.S., 2007. Spectrum of breast cancer in Asian women. *World Journal of Surgery*, 31, pp.1031–1040.
- Agnieszka, B. and Kamilla, B., 2018. Quality of Life and PTSD Symptoms, and Temperament and Coping with Stress. *Frontiers in Psychology*, 9, pp. 1-8.
- Baheux, K., Yoshizawa, M., Seki, K. and Handa, Y., 2006. Virtual Reality Pencil and Paper Tests for Neglect: A Protocol. *CyberPsychology & Behavior*, 9(2), pp.192-195.
- Baider, L., and De-Nour, A. K., 1997. Psychological distress and intrusive thoughts in cancer patients. *The Journal of nervous and mental disease*, 185(5), pp.346-348
- Biocca, F. and Levy, M., 1995. Communication in The Age of Virtual Reality. Hillsdale, N.J.: L. Erlbaum Associates, pp.115-117.
- Bisson, J., Roberts, N., Andrew, M., Cooper, R. and Lewis, C., 2013. Psychological therapies for chronic post-traumatic stress disorder (PTSD) in adults. *Cochrane Database of Systematic Reviews*.
- Bodenmann, G., 2005. Dyadic coping and its significance for marital functioning.
- Botella, C., Serrano, B., baños, R. and García-Palacios, A., 2015. Virtual reality exposure-based therapy for the treatment of post-traumatic stress disorder: a review of its efficacy, the adequacy of the treatment protocol, and its acceptability. *Neuropsychiatric Disease and Treatment*, p.2533.



Brutzman, D., 1998. The virtual reality modeling language and Java. *Communications of the ACM*, 41(6), pp.57-64.

Cai, L., 2017. On the current situation and development trend of VR virtual reality in China. *Modern Communication: Academic Edition*, (16), p.197.

Canadian Cancer Society, 1988. *Canadian Cancer Statistics*. Toronto: Canada, 1-48.

Carey, L.A., Perou, C.M., Livasy, C.A., Dressler, L.G., Cowan, D., Conway, K., Karaca, G., Troester, M.A., Tse, C.K., Edmiston. S., Deming. S.L., Geradts, J., Cheang, M.C., Nielsen, T.O., Moorman, P.G., Earp, H.S. and Millikan, R.C., 2006. Race, Breast Cancer Subtypes, and Survival in the Carolina Breast Cancer Study. *2006 American Medical Association*, 295(21), pp.2491-2502.

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E. and Ivkovic, M., 2010. Augmented reality technologies, systems and applications. *Multimedia Tools and Applications*, 51(1), pp.341-377.

Chen, Q., Zhang C., Cheng, K., 2018. Revision of Posttraumatic Growth Inventory Among Teachers in Wen-chuan Earthquake. *Studies of Psychology and Behavioral*, 16(5), pp:670-677.

Chen, W. and Zheng, R., 2015. Incidence, mortality and survival analysis of breast cancer in China. *Chinese Journal of Clinical Oncology*, 42, pp.668-674.

Chen, Y., Zhu, Z., 2018. Acceptance and Commitment Therapy for Posttraumatic Stress Disorder: A Review. *Chinese Journal of Clinical Psychology*, 26(01), pp.206-208.

Cook, J. M., Dinnen, S., Simiola, V., Thompson, R., & Schnurr, P. P., 2014. VA residential provider perceptions of dissuading factors to the use of two evidence-based PTSD treatments. *Professional Psychology: Research and Practice*, 45(2), p.136.

Courtois, C., Sonis, J., Brown, L., Cook, J., Fairbank, J., Friedman, M., Gone, J., Jones, r., Greca, A., Mellman, T., Roberts, J. and Schulz, P., 2017. Clinical Practice Guideline for the

Treatment of Posttraumatic Stress Disorder (PTSD) in Adults. Washington (DC): American Psychological Association.

Derogatis, L., 1983. The Prevalence of Psychiatric Disorders Among Cancer Patients. *JAMA: The Journal of the American Medical Association*, 249(6), p.751.

DiMauro, J., 2014. Exposure Therapy for Posttraumatic Stress Disorder: A Meta-Analysis. *Military Psychology*, 26(2), pp.120-130.

Ebright, P. and Lyon, B., 2002. Understanding Hope and Factors That Enhance Hope in Women With Breast Cancer. *Oncology Nursing Forum*, 29(3), pp.561-568.

Ehlers, A. and Clark, D., 2000. A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy*, 38(4), pp.319-345.

Elisabeth, K. R., 1969. *On Death & Dying*. New York: Touchstone, pp.12-14.

Enache, R., 2012. The relationship between anxiety, depression and self-esteem in women with breast cancer after surgery. *Procedia - Social and Behavioral Sciences*, 33, pp.124-127.

Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM. Cancer incidence and mortality worldwide: IARC CancerBase No.10. GLOBOCAN 2008[J]. Lyon: International Agency for Research on Cancer, 2010.

Ferrell, B. R., Grant, M., Funk, B., Garcia, N., Otis-Green, S., & Schaffner, M. L., 1996. *Quality of life in breast cancer*. *Cancer practice*, 4(6), pp.331-340.

Frank, B. and Mark R, L., 1995. *Communication In The Age Of Virtual Reality*. 1st ed. New Jersey: Lawrence Erlbaum, pp.115-117.

Frank, B. and Mark R, L., 1995. *Communication In The Age Of Virtual Reality*. 1st ed. New Jersey: Lawrence Erlbaum, pp.120.

Gabriel, N. and Hortobagyi, M.D., 1998. Treatment of Breast Cancer. *The New England Journal of Medicine*.

Garcia-Palacios, A., Hoffman, H., Carlin, A., Furness, T. and Botella, C., 2002. Virtual reality in the treatment of spider phobia: a controlled study. *Behaviour Research and Therapy*, 40(9), pp.983-993.

Gaudiano, B., 2008. Cognitive-behavioural therapies: achievements and challenges. *Evidence-Based Mental Health*, 11(1), pp.5-7.

Gayle Beck, J., Palyo, S. A., Winer E. H., Schwagler B. E., Ang, E. J., 2007. Virtual Reality Exposure Therapy for PTSD Symptoms After a Road Accident: An Uncontrolled Case Series. *Behavior Therapy*, 38(1), pp.39-48.

Giotakos, O., Tsirgogianni, K. and Tarnanas, I., 2007. A virtual reality exposure therapy (VRET) scenario for the reduction of fear of falling and balance rehabilitation training of elder adults with hip fracture history. *2007 Virtual Rehabilitation*, pp. 155-158.

Gopalan, M., 2013. Prevalence of psychiatric disorders among cancer patients admitted in a tertiary care centre. *Eur. Psychiatry*, 28(1).

Greenleaf, W., 2019. How Virtual And Augmented Reality Will Transform Healthcare.

Green, M. and Raina, V., 2008. Epidemiology, screening and diagnosis of breast cancer in the Asia-Pacific region: Current perspectives and important considerations. *Asia-Pacific Journal of Clinical Oncology*, 4, pp.S5-S13.

Hasson-Ohayon, I., Tuval-Mashiach, R., Goldzweig, G., Levi, R., Pizem, N. and Kaufman, B., 2015. The need for friendships and information: Dimensions of social support and posttraumatic growth among women with breast cancer. *Palliative and Supportive Care*, 14(4), pp.387-392.

Hermelink, K., Bühner, M., Sckopke, P., Neufeld, F., Kaste, J., Voigt, V., Münzel, K., Wuerstlein, R., Ditsch, N., Hellerhoff, K., Rjosk-Dendorfer, D., Braun, M., von Koch, F., Härtl, K.,

Hasmüller, S., Bauerfeind, I., Debus, G., Herschbach, P., Mahner, S. and Harbeck, N., 2017. Chemotherapy and Post-traumatic Stress in the Causation of Cognitive Dysfunction in Breast Cancer Patients. *JNCI: Journal of the National Cancer Institute*, 109(10).

Highland, K., Kruger, S. and Roy, M., 2015. If You Build It, They Will Come, But What Will Wounded Warriors Experience? Presence in the CAREN. *Studies in Health Technology and Informatics*, 219, pp.23-27.

Holmqvist, K. and Frisé, A., 2010. Body dissatisfaction across cultures: Findings and research problems. *European Eating Disorders Review*, 18(2), pp.133-146.

iResearch, 2017. China Virtual Reality (VR) Industry Research Report-Market Data. [online] Report.iresearch.cn. Available at: <[http://report.iresearch.cn/report\\_pdf.aspx?id=3016](http://report.iresearch.cn/report_pdf.aspx?id=3016)> [Accessed 15 April 2020].

Jasmin, C., Lê, M.G., Marty, P. and Herzberg, R., 1990. Evidence for a link between certain psychological factors and the risk of breast cancer in a case-control study. *Annals of Oncology*, 1(1), pp.22-29.

Jerald, J., 2015. *The VR Book: Human-Centered Design for Virtual Reality*. 1<sup>st</sup> edn. Association for Computing Machinery and Morgan & Claypool.

Jung, J., and Lee, S. H., 2006. Cross-cultural comparisons of appearance self-schema, body image, self-esteem, and dieting behavior between Korean and U.S. women. *Family and Consumer Sciences Research Journal*, 34, pp.350–365.

Kanade, T., Narayanan, P. & Rander, P. W., 2000. Method for Creating Virtual Reality. United States of America, Patent No. 6,084,979.

Kangas, M., Henry, J. and Bryant, R., 2002. Posttraumatic stress disorder following cancer. *Clinical Psychology Review*, 22(4), pp.499-524.

Kovacs, M., Rush, A. J., Beck, A. T., & Hollon, S.D., 1981. Depressed outpatients treated with cognitive therapy or pharmacotherapy. *Archives of General Psychiatry*, 38, pp.33-39.

Lehto, R. H., 2017. Psychosocial challenges for patients with advanced lung cancer: interventions to improve well-being. *Lung Cancer*, pp.79–90.

Li, W., Ma, L., Li, X. and Zhou, C., 2015. Survey of post-traumatic stress disorder of breast cancer inpatients and its influencing factors. *Chinese Nursing Research*, 29(1B), pp.174-178.

Li, W., Li, J., Ma, L. and Li, X., 2015. Analysis of the related factors of post - traumatic stress disorder in the hospitalized patients with breast cancer and nursing tactics. *Wulumuqi Nursing Research*, 12, pp.1-3.

Li, X., n.d. Study on Post-traumatic Stress Disorder and Its Influencing Factors in Breast Cancer Inpatients. *China Continuing Medical Education*, 10(26), pp.104-106.

Lou, Y., 2017. “VR + medical”: Enhance the immersion of the experimenter. *China Academic Journal Electronic Publishing House*, 007.

Manos, D., Sebastián, J., José Bueno, M., Mateos, N. and de la Torre, A., 2005. Body Image in Relation to Self-Esteem in a Sample of Spanish Women with Early-Stage Breast Cancer. *Psicooncología*, 2(1), pp.103-116.

Maughan, K., Lutterbie, M. and Ham, P., 2010. Treatment of Breast Cancer. *Am Fam Physician*, 81(11), pp.1339-1346.

McGovern, M., Drake, R., Merrens, M.R., Mueser, K. and Brunette, M., 2014. *Family Program: Education, Skills, and Therapy for Families of People with Co-occurring Disorders*. Revised ed. Hazelden Publishing.

McLay, R., Baird, A., Webb-Murphy, J., Deal, W., Tran, L., Anson, H., Klam, W. and Johnston, S., 2017. A Randomized, Head-to-Head Study of Virtual Reality Exposure Therapy for Posttraumatic Stress Disorder. *Cyberpsychology, Behavior, and Social Networking*, 20(4), pp.218-224.

Menelas, B., Haidon, C., Ecrepont, A. and Girard, B., 2018. Use of virtual reality technologies as an Action-Cue Exposure Therapy for truck drivers suffering from Post-Traumatic Stress Disorder. *Entertainment Computing*, 24, pp.1-9.

McGregor, B., Dolan, E., Murphy, K., Sannes, T., Highland, K., Albano, D., Ward, A., Charbonneau, A., Redman, M. and Ceballos, R., 2015. Cognitive Behavioral Stress Management for Healthy Women at Risk for Breast Cancer: A Novel Application of a Proven Intervention. *Annals of Behavioral Medicine*, 49(6), pp.873-884.

McLay, R., McBreien, C., Wiederhold, M. and Wiederhold, B., 2010. Exposure Therapy with and without Virtual Reality to Treat PTSD while in the Combat Theater: A Parallel Case Series. *Cyberpsychology, Behaviour and Social Networking*, 13(1), pp.36-42.

Michael, A., Matthew, C., Jamie, S. and Thomas, M., 1998. Posttraumatic Stress Disorder After Treatment for Breast Cancer: Prevalence of Diagnosis and Use of the PTSD Checklist—Civilian Version (PCL–C) as a Screening Instrument. *Journal of consulting and clinical psychology*, 66, pp.586-590.

Mishkind, M., Norr, A., Katz, A. and Reger, G., 2017. Review of Virtual Reality Treatment in Psychiatry: Evidence Versus Current Diffusion and Use. *Current Psychiatry Reports*, 19(11).

Mo., B., 1992. Modesty, sexuality, and breast health in Chinese-American women, In Cross-cultural Medicine-A Decade Later. *The Western Journal of Medicine*, 157(Special Issue), pp. 260-264.

NCI, NCI Dictionary of Cancer Terms. n.d. breast cancer. [online] Available at: <<https://www.cancer.gov/publications/dictionaries/cancer-terms/def/breast-cancer?redirect=true>> [Accessed 15 April 2020].

Neta, O., 2020. *Transcriptomic Analysis Of Immune System Genes In Different Breast Cancer Subtypes*. Postgraduate. Institute of Pharmaceutical Sciences, Graduate Program in Biochemistry and Molecular Biology, Federal University of Alagoas, Maceió.

Nelson, R., 2013. Is virtual reality exposure therapy effective for service members and veterans experiencing combat-related PTSD? *Traumatology*, 19(3), pp.171-178.

O' Connor, M., Christensen, S., Jensen, A. B., Møller, S., & Zachariae, R., 2011. How traumatic is breast cancer? Post-traumatic stress symptoms (PTSS) and risk factors for severe PTSS at 3 and 15 months after surgery in a nationwide cohort of Danish women treated for primary breast cancer. *British Journal of Cancer*, 104(3), pp.419-426.

Oyama, H., Wakao, F., and Okamura, H., 1997. Virtual reality support system in palliative medicine. *Studies in health technology and informatics*, 39, pp.60-63.

Parkin, D.M., Bray, F., Ferlay, J. and Pisani, P., 2005. Global Cancer Statistics 2002. *CA: A Cancer Journal for Clinicians*, 55, pp.74–108.

Perry, J., VanDenKerkhof, E., Wilson, R. and Tripp, D., 2017. Guided Internet-based Psycho-educational Intervention Using Cognitive Behavioral Therapy and Self-management for Individuals with Chronic Pain: A Feasibility Study. *Pain Management Nursing*, 18(3), pp.179-189.

Reger, G., Koenen-Woods, P., Kimberlee, Z., Derek, S., Kevin, H., Barbara, R., Joann, D., Albert, R., Amanda, E., Nancy, S., Matthew, M., Mark, R. and Gregory, G., 2016. Randomized Controlled Trial of Prolonged Exposure Using Imaginal Exposure vs. Virtual Reality Exposure in Active Duty Soldiers With Deployment-Related Posttraumatic Stress Disorder (PTSD). *Journal of Consulting and Clinical Psychology*.

Riva, G., 2009. Virtual reality: an experiential tool for clinical psychology. *British Journal of Guidance & Counselling*, 37(3), pp.337-345.

Rizzo, A., Cukor, J., Gerardi, M., Alley, S., Reist, C., Roy, M., Rothbaum, B. and Difede, J., 2015. Virtual Reality Exposure for PTSD Due to Military Combat and Terrorist Attacks. *Journal of Contemporary Psychotherapy*, 45(4), pp.255-264.

Rizzo, A., John, B., Newman, B., Williams, J., Hartholt, A., Lethin, C. and Buckwalter, J., 2013. Virtual Reality as a Tool for Delivering PTSD Exposure Therapy and Stress Resilience Training. *Military Behavioral Health*, 1(1), pp.52-58.

Popovic, S., Slamic, M. and Cosic, K., 2020. *Scenario Self-Adaptation In VR Exposure Therapy For PTSD*. Postgraduate. University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia.

Rothbaum, B., Hodges, L., Alarcon, R., Ready, D., Shahar, F., Graap, K., Pair, J., Hebert, P., Gotz, D., Wills, B. and Baltzell, D., 1999. Virtual reality exposure therapy for PTSD Vietnam veterans: A case study. *Journal of Traumatic Stress*, 12(2), pp.263-271.

Rothbaum, B., Price, M., Jovanovic, T., Norrholm, S., Gerardi, M., Dunlop, B., Davis, M., Bradley, B., Duncan, E., Rizzo, A. and Ressler, K., 2014. A Randomized, Double-Blind Evaluation of D-Cycloserine or Alprazolam Combined with Virtual Reality Exposure Therapy for Posttraumatic Stress Disorder in Iraq and Afghanistan War Veterans. *American Journal of Psychiatry*, 171(6), pp.640-648.

Sherman, W. and Craig, A., 2003. *Understanding Virtual Reality*. San Francisco: Morgan Kaufmann Publishers, pp.71.

So, W., Marsh, G., Ling, W., Leung, F., Lo, J., Yeung, M. and Li, G., 2010. Anxiety, depression and quality of life among Chinese breast cancer patients during adjuvant therapy. *European Journal of Oncology Nursing*, 14(1), pp.17-22.

Sun, X., Yan, L. and Li, Y., 2007. The outlook of virtual reality technology in medical. *China Academic Journal Electronic Publishing House*, (5), pp.18-20.

Tae, Y., Heitkemper, M. and Kim, M., 2011. A Path Analysis: A Model of Depression in Korean Women with Breast Cancer-Mediating Effects of Self-Esteem and Hope. *Oncology Nursing Forum*, 39(1), pp.E49-E57.



Taffou, M., Guerchouche, R., Drettakis, G., & Viaud-Delmon, I., 2013. Auditory–visual aversive stimuli modulate the conscious experience of fear. *Multisensory Research*, 26(4), 347-370.

Tedstone, J. E., and Tarrier, N., 2003. Posttraumatic stress disorder following medical illness and treatment. *Clinical Psychology Review*, 23, pp.409–448.

Tian, Y., Zhou, X., Wu, X., and Zeng, M., 2016. The Moderating Role of Emotion Regulation between PTSD and PTG. *Chinese Journal of Clinical Psychology*, 24(03), pp.479-483.

Yuan, R., 2018. *Analysis And Prediction Of Mobility And Mortality Trend Of Breast Cancer In Chinese Women Based On GBD Big Data*. Ph.D. Wuhan University.

Topley, M., 1958. *The Organization and Social Function of Chinese Women's Chai T'ang in Singapore*. Postgraduate. University of London.

Von Ah, D., Kang, D. and Carpenter, J., 2007. Stress, optimism, and social support: Impact on immune responses in breast cancer. *Research in Nursing & Health*, 30(1), pp.72-83.

Wang, Y., 2016. Study of Effects of Cognitive-Behavioral Therapy (CBT) On The Posttraumatic Growth (PTG) Of Breast Cancer Patients. Postgraduate. DaLian medical university.

Wang, Y. and Ollendick, T., 2001. A Cross-Cultural and Developmental Analysis of Self-Esteem in Chinese and Western Children. *Clinical Child and Family Psychology Review*, 4(3), pp.253-271.

Wild, C.P., Weiderpass E., Stewart BW and editors, 2020. World Cancer Report: Cancer Research for Cancer Prevention. Lyon, France: International Agency for Research on Cancer. Available from: <http://publications.iarc.fr/586>. Licence: CC BY-NC-ND 3.0 IGO.

Wolf, M. and Witke, R., 1975. *Women in Chinese Society*. Stanford: Stanford University Press.

Wong-Kim, E., Sun, A., Merighi, R. and Edward, A.C., 2005. Understanding Quality-of-Life Issues in Chinese Women With Breast Cancer: A Qualitative Investigation. *Cancer Control*, pp.6-21.

Xiao, Y. and Li, X., 2017. Application and Comparison of Exposure and Narrative the Therapy in the Psychological intervention of PTSD. *China Journal of Health Psychology*, 25(12), pp.1917-1921.

Yehuda, R., 2002. Post-traumatic stress disorder. *The New England Journal of medicine*, 346, pp.108–114.

Yuan, C. and Yang, B., 2017. Research on the Application of VR Technology in Medical Treatment. *Modern Information Technology*, 2(3), pp.102-104.

Yuan, G., Xu, W., Liu, Z., & An, Y., 2018. Resilience, posttraumatic stress symptoms, and posttraumatic growth in Chinese adolescents after a tornado: The role of mediation through perceived social support. *The Journal of nervous and mental disease*, 206(2), pp.130-135.

Yuan, R., 2018. *Analysis And Prediction Of Mobility And Mortality Trend Of Breast Cancer In Chinese Women Based On GBD Big Data*. Ph.D. Wuhan University.

Zhang, L., 2009. Stress Disorder. BeiJing: People’s Education Press, pp.1-10.

Zhang, Q., 2019. *Symptoms and Psychosocial factors of post-traumatic stress disorder in breast cancer patients*. Postgraduate. Shihezi University.

Zhang, Z. and Su, X., n.d. The application of VR technology. *China Academic Journal Electronic Publishing House*, pp.153-156.

Zhao, H., Zhang, J., Lu, Y., & Jin, J., 2019. Neoadjuvant chemotherapy in combination with surgery in the treatment of local advanced breast cancer. *Pakistan journal of medical sciences*, 35(5), pp.1402–1407.

Zhu, L., Xing, W., Lu, K., Hu, M. and Zhang, G., 2019. Correlation between cortisol levels and clinical symptoms in patients with post-traumatic stress disorder. *Chinese General Practice*, 11, pp. 1297-1301.

Zhu, L., Xu, W., An, Y. and Chen, X., 2018. The effect of PTSD symptoms on quality of life for breast cancer: Mediating effect of depression and caregivers pressure. *China Journal of Health Psychology*, 26(2), pp.225-229.