PROVIDING INFORMATIONAL SUPPORT TO HIV+ WOMEN IN A VIRTUAL ENVIRONMENT: A CASE STUDY COMPARING THE EFFECTS OF VIRTUAL REALITY AND PAPER MEDIA FOR CONTENT DELIVERY

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Sarah Brown

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Edwin H. Blake

Abstract

South Africa has one of the highest HIV+ prevalence rates in the world [1]. Furthermore, social support is beneficial to HIV+ people. Informational support is a type of social support which is used to increase one's knowledge base [2]. Hayes *et al.* state that informational support is especially beneficial for those in the early stages of HIV infection [3]. Computer technologies have been used successfully in providing informational support to their users. However, virtual reality (VR) is a relatively unexplored technology in South Africa, and we feel it is a highly appropriate medium for a context where users have little or no prior computing experience. Traditionally, computer interfaces require users to have a learned skillset, but a VR interface does not necessarily require this as it maps more directly to users' natural interaction techniques with the real world. A key benefit of a virtual environment (VE) is the interactivity and user involvement that it offers through a high degree of navigation and interaction with objects [4]. VR may, initially, seem to be an expensive technology to use in a developing country but it is possible to make use of desktop VR on a consumer-grade PC relatively affordably.

This dissertation presents a comparison of the effects of two media, VR and paper (i.e. pamphlets) in communicating supportive information to an HIV+ sample group. We created a VE to provide social and informational support for HIV+ people in the South African context. The design of the VE placed emphasis on creating a typically South African space which users could recognize and find familiar. Our research focused on two rooms containing virtual agents and points of possible interaction: the lounge and the kitchen. In the lounge, a HIV/Aids support group was simulated while the kitchen contained two areas which presented nutritional informational support: *Diet* and *Cleanliness & Hygiene.*

We conducted a pre- post-test study with 22 HIV+ women at two clinics in Cape Town. Participants were randomly assigned into one of three groups. One group experienced the informational VE (*VE*), one group received information pamphlets (*Text*), the control group who received no information until the end of the study (*Ctrl*). Participants attended three experiment meetings over a five week period. Participants completed two 3-day food diaries and completed questionnaires that provided measurement for two sets of variables: *Food Safety Behaviours* (a measure of knowledge of correct food and water safety practices to prevent food-borne illnesses) and *Dietary Quality* (measure of the diet quality – in terms of quantity, variety, water intake and vitamin supplements, as well as specific food items for the prevention of stomach ailments, a common complaint of HIV infection). While we found no differences between the *Text* and *Ctrl* groups, the *VE* group showed a significant improvement in consuming two (of three) specific food items recommended for the prevention of stomach complaints. This is a particularly striking result given that more than half the participants stated that they routinely did not have enough money to buy food let alone specific healthy foods. The area that contained the information related to stomach complaints was the last imagery experienced by all VE participants. That it was the only area that showed improvement highlights how careful VE authors should be in choosing the actual content for the environment, as well as how that content is delivered. Despite very minimal computing experience and only short training sessions, all participants mentioned that they found the VE easy to use and enjoyed their experience of it. Our results show that VR can indeed be used to deliver informational content to HIV+ women in South Africa.

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Contents

Glossary

Aids	Acquired Immunodeficiency Syndrome
FAO	Food and Agriculture Organization
HIV	Human Immunodeficiency Virus
PLWHA	People living with HIV/Aids
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV/Aids
VE	Virtual Environment
VR	Virtual Reality
WHO	World Health Organization

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Chapter 1

Introduction

> *"I would choose to be Andile because Andile is got everything that means, in his life. Like the house, the life, the life that Andile is living ... he is living positively. He don't hide HIV. His HIVs. He don't drag, take the HIV under the blanket. He just talking about HIV. He's not scared anymore about his HIV. As a result, he is living positive."*
>
> [Participant 25]

Andile is a virtual agent created for this research, and presented to an HIV+ South African woman in a virtual environment (VE) application. The user had never used a computer prior to experiencing this low-cost desktop virtual reality (VR) application. The opening quotation above describes her response.

In 2005, it was estimated that 38.6 million people were living with HIV worldwide and that 2.8 million people had lost their lives to Aids [1]. It is well known that South Africa has one of the largest HIV+ populations in the world. Combined with the limited resourced of a developing world economy, this presents significant challenges for the South African health sector. Novel approaches are needed that provide timely, accurate information to people living with HIV/Aids. The development of methods and tools to extend the reach of health care professionals is a major research interest.

1.1 Research Aims

The primary aim of this research was to investigate the effectiveness of VR as a communication medium for social support to HIV+ women living in South Africa. Information support (a subset of social support) is the provision of guidance and information that equips the receiving individuals with skills and knowledge to alleviate stressors in their lives [3, 5-7]. To measure the effectiveness of VR as a communication medium, it was compared to the more tradition medium of paper-based booklets.

The secondary aim of this research was to investigate whether VR technology was usable for individuals with little or no prior computing experience. With the low level of computer literacy in South Africa, it is important that a VR system both empowers novice users, and is usable. Additionally, in the face of the limited resources in the public health sector, the amount of time required for take-up (i.e. training) of a system needs to be minimised.

Most of the participants that experienced the VE had never used a computer before the VR simulation. Despite this, these individuals had very positive feedback for many areas of the system, including the informative content and ease of use. Many participants felt empowered by the use of the system.

1.2 Research Overview

The intended target population for this research were young pregnant women: They are highly over-represented in HIV positive populations (in South Africa, about 30% of all pregnant women are HIV positive [8]), making the development of support tools for this group an important goal. It was important that the participants involved in this study were representative of the intended target users of the VR therapeutic intervention. We thus recruited participants from two government health care facilities in Cape Town. Both facilities catered for HIV+ pregnant women, and therefore most participants were recent mothers, heavily pregnant and even went into labour during the experiment. Many also received their HIV+ diagnosis as a result of these pregnancies. Considering the sensitivity around HIV/Aids a great deal of effort was placed on ethical considerations. Approval was obtained from the Science Faculty Ethics Board of the University of Cape Town for this research study.

We wanted to create an environment that included information on many aspects of everyday life. One of the key advantages of VR over other media is the interactivity that it provides its users and for this research we wanted to design a VE that utilized this fully. We chose to focus on nutritional information for the VE content as it provided a range of interactivity as well as a large quantity of information.

In a literature review of nutritional care and support in Sub-Sahara Africa, key components of nutritional programs for HIV+ individuals were identified [9]. Two of these are suitable for presentation within a VE and were thus included in this research. These are:

- Nutrition education and counselling with the aim of increasing consumption of key recommended food items
- Interventions aimed at water, hygiene and food safety to prevent food-borne illnesses

Stigma surrounding HIV/Aids in South Africa is high. A well designed VE can provide a safe, warm environment that comforts the user, and can also encourage anonymity. This was seen in the first study of this research program where Hamza *et al.* created a virtual support group set around a campfire in a forest environment. Based on user feedback, the HIV narratives were adapted and included in the VE designed for this research. The issue of stigma also affects the design of experiment documents, particularly those that leave the experiment venue. This was seen with the measurement instrument used to record dietary intake in the form of a 3-Day Food Diary, and it was important that no references were made to the terms *HIV* or *Aids*.

VR technology and equipment is generally associated with high costs, and in a developing country such as South Africa, it is important that resources are not wasted. However, we shall see that that desktop VR is both affordable and appropriate for the South African market. Consumer-grade desktop PCs are now capable of producing sensory-rich environments, and use standard headphones for audio output. The most expensive aspect of such an intervention is the expertise (ranging from 3D modellers, animators to content specialists) and there is a considerable amount of work involved in creating a VE such as the one described in this dissertation. We shall see in this study that positive results were seen with the participants that viewed the VE and these benefits outweigh these costs.

1.3 Research Questions

The two components identified for inclusion in the VE were categorized into two concepts that could be measured and statistically analysed. These were *Dietary Quality* and *Food Safety Knowledge*. In order to evaluate the effectiveness of the VE as a medium for communicating nutritional information to people living with HIV/Aids (PLWHA), two research questions were identified. An effective communicative medium would be one that resulted in a positive change in participants' daily behaviours. Each research question is broken down into two hypotheses which focus on the two identified components.

1.3.1 Research Question 1: Are VEs effective in providing informational support to HIV+ people?

The first research question is broken down into the following two hypotheses:

Hypothesis 1: An HIV+ person who experiences a VE rich in nutrition information will show an improvement in their dietary quality.

Hypothesis 2: An HIV+ person who experiences a VE rich in nutrition information will see an improvement in their knowledge of food safety issues.

If both these hypotheses are proved correct, then VEs can be viewed as an effective communication medium for providing informational support to HIV+ people.

1.3.2 Research Question 2: Are VEs better at providing informational support to HIV+ people, as compared to the more traditional paper medium?

The process of creating a VE is timely and resource-consuming. We were interested in investigating the possibility of using such a medium for our target audience, and thus compared it to a cheaper, more common form of communication media: paper booklets. Our second research question explores this by comparing groups of HIV+ individuals who experienced the VE, against those who received only a paper-based description of the informational content.

Hypothesis 3: An HIV+ person who experiences a VE rich in nutrition information will show more improvements in their dietary quality than an HIV+ person who experiences the same content presented in a booklet.

Hypothesis 4: An HIV+ person who experiences a VE rich in nutrition information will show more improvements in their knowledge of food safety behaviours than an HIV + person who experiences the same content in a booklet.

If both these hypotheses are proved correct, then VEs can be viewed as a better communication medium for providing informational support to HIV+ people, as compared to the a paper-based medium.

1.4 Dissertation Outline

Chapter 2 In this chapter background information is presented in the form of a literature review. The theoretical background of this research draws from

multiple disciplines and this chapter gives the reader a review of the most important topics in these disciplines.

Chapter 3 In Chapter 3, the design and implementation of the VE is presented. Design criteria and motivation for the informational content are given. The most important supporting document used during VE design is the storyboard and a detailed description of this is presented. The chapter concludes with the technical details of the VE components and how these are combined to create the final VR application.

Chapter 4 In the fourth chapter, the experimental design is discussed. A pre- post-test design was chosen to assess the impact of experiencing an informational VE in two broad areas (*Dietary Quality* and *Food Safety Knowledge*). In this chapter we discuss the questionnaires and other supporting experiment documents, the materials used and the participants. We conclude with the procedure followed in conducting the pre- post-test experiment underlying this research.

Chapter 5 Chapter 5 contains the results obtained after statistical analyses were done on the data measured during the experiments. We report on both quantitative data (in the areas of *Dietary Quality* and *Food Safety Knowledge*) and qualitative data (from interviews conducted after the VE experience).

Chapter 6 In Chapter 6, a discussion is presented of the results obtained in the previous chapter. In so doing, the research questions of this study are addressed.

Chapter 7 And in this final chapter, conclusions from this research are presented. Recommendations for future work are also given.

Chapter 2

Background

In order to build a VE that provides informational support to HIV+ women, we drew from many different disciplines. In this chapter, we start by reviewing the current HIV/Aids situation in South Africa, with a particular emphasis on the areas that affect the design and implementation of a VR application. This is followed by a description of the types of social support, all of which are beneficial to people living with HIV/Aids. Information and communication technologies (ICT) have been used to provide such support, and we present four examples. Virtual reality has benefits that we think favour the target users of this research. These are individuals with minimal (if any) prior computing experience. Four relevant VR applications are presented. It was important that the factual information presented is highly applicable to HIV+ individuals and so, a discussion of nutritional support and the associated benefits for HIV+ people is given. Finally, the literature review concludes with different evaluation strategies that should be used when evaluating the effectiveness of nutritional intervention programs.

2.1 HIV in South Africa

South Africa has one of the largest HIV+ populations in the world [1, 10]. In the 2006 report on the global HIV/Aids situation [1], the HIV/Aids epidemic in South Africa was highlighted as one of the "worse in the world, and shows no evidence of decline" [1].

2.1.1 Prevalence Rates and Target Users

In the UNAIDS report of the global Aids epidemic in 2006, the authors observed the "disproportionate impact of the Aids epidemic on women, especially in sub-Saharan Africa where, on average, three women are HIV-infected for every two men. Among young people (15–24 years), that ratio widens considerably, to three young women for every young man." [1]. Since 1990, the South African government, through its Department of Health, has conducted annual surveys of HIV infection by looking at data collected from antenatal clinics. In the National HIV and Syphilis Sero-Prevalence Survey in South Africa in 2005, HIV prevalence among clinic attending women was 30.2% [11].

Table 2-1 below shows the prevalence rates, broken down into age groups, against the past 5 years data collected in this series of surveys [11] and [8]. As can be seen below, pregnant South African women between the ages of 25 and 29 have the highest prevalence rate (39.5%), making this group of individuals the target for this research.

Table 2-1: HIV prevalence by age group among antenatal clinic attendees, South Africa: 2003-2005

Age Group	2000 Prevalence (%)	2001 prevalence (%)	2002 Prevalence (%)	2003 Prevalence (%)	2004 Prevalence (%)	2005 Prevalence (%)
< 20	16.1	15.4	14.8	15.8	16.1	15.9
20-24	29.1	28.4	29.1	30.3	30.8	30.6
25-29	30.6	31.4	34.5	35.4	38.5	39.5
30-34	23.3	25.6	29.5	30.9	34.4	36.4
35-39	15.8	19.3	19.8	23.4	24.5	28.0
40+	11.0	9.8	17.2	15.8	17.5	19.8
National	**24.5**	**24.8**	**26.5**	**27.9**	**29.5**	**30.2**

2.1.2 Public Health Sector in South Africa

Most South Africans rely on public health services, since private medical aid schemes and medical insurance are only affordable by 18% of the population [12]. However, there are severe inefficiencies in the South African public health sector even though they service approximately 40 million individuals. Firstly, there is a severe shortage of qualified health care workers. In 1993, the World Health Organization [13] reported that South Africa had 1640 persons per physician (contrast that figure with 370 for Germany, 630 for the USA, 719 for Albania and 1001 for Mexico). Reasons behind this shortage include professionals who leave the country for more favourable working conditions overseas. Also, due to the high stress levels and low salaries, many health care workers in South Africa prefer to work in the private sector. Additionally, HIV prevalence is also extremely high within health care employees [14] [15], causing absenteeism from the workplace, and a decrease in numbers of public health care workers in general, due to mortality.

In summary, the public health sector is severely affected by HIV and Aids. With such a large number of people living with HIV/ Aids in South Africa who rely on this sector, there is an enormous need for accessible, therapeutic interventions that can help individuals cope. With staff shortages in the field, and hence the minimal amount of personalised time that a health care worker can give to patients, it is imperative that innovative solutions that provide timely, accurate information are made available.

2.1.3 Stigma and Discrimination

Another aspect of HIV/Aids in South Africa is that of stigma and discrimination. Although this is not unique to our country, it is an important concept to mention as it affects, among other factors, the accessibility of information available to individuals infected with, and affected by HIV/Aids. There are two types of stigma; external or enacted stigma where individuals experience actual acts of discrimination; and internal stigma, which refers to the shame associated with the stigma and the fear of being discriminated against [16].

In a joint research project between POLICY Project SA, SA National Department of Health, Centre for the Study of Aids (CSA) and USAID, seven external and five internal stigmas were identified [16]. These indicators were categorised into themes commonly experienced by HIV-infected individuals in South Africa. A complete summary is presented in their report. The indicators that may have an effect for this particular research follow.

An external indicator of stigma is the unwillingness to invest in people living with HIV/Aids. In their survey, it was found that individuals were offered less training, promotion and responsibility within their organisations when their HIV status was disclosed. Another external indictor is that of discrimination when people living with

HIV/Aids have been denied services such as medical and financial due to their HIV status. External stigma can result in HIV+ individuals experiencing avoidance and rejection from their communities. A particularly relevant internal stigma indicator occurs when people choose not to access services and opportunities out of fear of their status becoming known to others [16].

In summary, with South Africa having the largest population of HIV + people in the world, coupled with the limited resources typical of a developing world economy, presents significant challenges for the South African health sector. The shortage of qualified medical personnel to deliver care and accurate information is of major concern. The development of methods to extend the reach of health care professionals is thus a major research interest. Additionally, due to the high level of both self-imposed and external stigma surrounding HIV infection, it is vital that support systems and intervention programs designed for people living with HIV/Aids allow and encourage anonymity for its participants.

2.2 Social Support

In an editorial review of social support and HIV, Green [17] provides a general definition stating that social support is a collective term relating to different aspects of social relationships. This includes the existence, quantity and type of interpersonal relationships, the functional content of these relationships, as well as the perceived quality or adequacy of this support [18].

There are three distinct types of social support [3, 5-7]. They are:

- **Emotional Support:** This involves the receipt of affection, comfort and encouragement.
- **Information Support:** This is the receipt of guidance and information. Providing informational support equips the individual with skills and knowledge to resolve and/or alleviate the stressors in their lives. In some literature, this is also known as guidance support.
- **Instrumental Support:** This type of social support can be described as practical assistance with daily living [7] and is also known as practical support or tangible support.

Research has shown that the presence of all three types of social support can contribute towards a reduction in the psychological distress associated with a chronic illness. Hays and his colleagues found all three types of social support to be associated with reduced depression, but also found informational support to be particularly important for HIV+ individuals in the early stages of HIV infection [3]. In another study, Singh and his colleagues found that availability of both informational and instrumental support were important determinants of improvements in quality of life for their participants [5].

2.3 Information & Communication Technologies for the Provision of Social Support

Information and social support can be provided in a number of ways. In a discussion of media in which this support can be provided, Smaglik and his colleagues identify a tradeoff between the economically feasible mass-produced booklets and pamphlets and the more expensive, time-consuming method of one-on-one consultations between individuals and their health care provider [19]. The authors feel that the key to a successful system for the

provision of support services is one that includes a range of tools or services, and allows for the user to tailor the system to suit their needs [19].

With such knowledge of the advantages of social support for HIV+ individuals, it is possible to look at computers to provide informational and emotional support to its users. Certain technologies and software can provide an environment where the user is able to choose the content and/or services they wish to experience, in an anonymous, non-threatening manner.

2.3.1 The Internet

Individuals with an Internet connected device can access a wealth of HIV-related factual information. A commonly available and utilized emotional support service is that of virtual support groups in which online communities communicate in chatrooms and forums. Participants can discuss and exchange advice within these spaces. An important advantage of this technology is the anonymity it allows.

However, as Gustafson *et al.* correctly point out, there are inherent problems with using the Internet as a technology for health care systems [20, 21]. The following questions should be addressed in this situation:

- Can patients and caregivers learn to navigate the Internet (familiarity with the hardware and software)?
- Are they willing to tie up their phone lines (and hence willing to pay for the time spent on the Internet)?
- Are they able to understand and effectively evaluate the information?

Additionally, users of an Internet-based health system may get scared due to the "mere quantity of information on the Internet" [20].

An important factor which is particularly important, in a developing country such as South Africa, where computer literacy is low, is the learning factor. The Internet is completely unregulated, making inaccurate dubious information available to naïve users. Issues such as this would need to be carefully addressed during training sessions. Even in a developed country such as the United States, the Children's Partnership found that at least 20% of Americans are faced with "content-related barriers to the benefits of the Internet". Some of these include a lack of localized information, literacy and language barriers and lack of cultural diversity [22].

Estimates of Internet penetration in South Africa do exist. From the World Fact Book, the Central Intelligence Agency in the United States state that were 5.1 million Internet users in our country in 2005 [23]. With the South African population estimated at 44 million, this represents 8.6% of South Africans having access to the Internet. Another source is the South African Advertising Research Foundation (SAARF). In the All Media and Products Survey (AMPS) in 2005, over 12,500 adult South Africans (16 years and older) were interviewed. Results from this indicated that only 5.9% people had used the Internet four weeks prior to the time of questioning. Also, in South Africa, having access to the Internet and computers in general is associated with high education levels, and consequently, higher paid incomes. Additionally, telecommunication costs in South Africa are one of the highest in the world, making it inaccessible for most of the population. Most South Africans do not currently have the means to use such a technology.

With the limitations of the Internet as a source of social support in South Africa, we turn to other information and communication technologies (ICTs) used for delivery of support.

2.3.2 The Comprehensive Health Enhancement Support System (CHESS)

David Gustafson and his colleagues from the University of Wisconsin-Madison developed a broad computer-based support program for individuals affected by a number of different health conditions. Users of the Comprehensive Health Enhancement Support System (CHESS) have access to tools that provide information, referrals, decision support and social support particular to a specific health condition [24]. Some of the CHESS modules include breast cancer, stress management, academic crisis, and HIV/Aids infection [24, 25]. The content provided through CHESS is thorough and comprises eleven inter-linked services. They are presented below in Table 2-2.

Table 2-2: Eleven inter-linked services that are provided through the Comprehensive Health Enhancement Support System (CHESS)

1. Questions and Answers	7. Assessment
2. Instant Library	8. Decision Aid
3. Getting Help/Support	9. Action Plan
4. Personal Stories	10. Health Charts
5. Ask an Expert	11. Dictionary
6. Discussion Group	

Numerous studies have been conducted on the type and frequency of CHESS usage among users. In these studies PCs or laptops were installed at participants' homes for between three and six month periods. The machines were connected to a central computer via a modem [24]. In one of these studies that examined the impact of the HIV/Aids module, Boberg *et al.* found CHESS to be a "heavily used and highly accepted means of providing information and support to HIV-infected individuals" [24]. In particular, use of the social support services (*Discussion Group* and *Personal Stories*) accounted for the majority of overall usage (79%). Information services, which comprised of the *Instant Library, Questions & Answers, Ask an Expert* and *Getting Help / Support* accounted for 17% of overall usage. The analysis services were the least used (4%), and consisted of *Decision Aid* and *Action Plan.*

An important finding from Boberg's study [24] and in other CHESS studies [21, 26] which has resonance in this research, is that CHESS usage was not affected by participants' income or educational levels. However, a difference was found in the *frequencies and types* of CHESS services used by different population groups. Gustafson and his colleagues conducted a study aimed at investigating whether CHESS is more beneficial to individuals in underserved communities [27]. Using race, education and lack of insurance as indicators, it was found that CHESS benefits were greater for disadvantaged participants [27]. While this is relevant and promising, it is not necessarily transferable to a South African population, since computer adoption and acceptance is different in each country.

Another interesting aspect of the CHESS system development is that of the noted possible extensions planned for future development. In order to further increase the accessibility of the application in the future, the team at the Center for Health System Research and Analysis at the University of Wisconsin-Madison, plan to add features such as graphics, sound, video and touch screens [24]. This would increase the interactivity, and would assist with improving accessibility to individuals who are not fully computer literate. However, it should be noted that CHESS is designed as a group of interlinked web pages, and this generally requires additional learning (such as navigation). This can be a substantial barrier to system adoption in a country such as South Africa where typical users have minimal (or no) prior computer exposure.

Considering the overwhelming high usage of the *Personal Stories* and *Discussion Group* services (79%), it is clear that people infected with HIV have a need for such social support services. It is important that computer applications developed for these individuals, include

these key services at a minimum. For this research, it was not possible to include an interactive forum (i.e. the *Discussion Group* service), but the need for personal accounts of living with HIV were included because of the results observed in CHESS studies.

2.3.3 ComputerLink

ComputerLink was developed by a team of researchers at Case Western Reserve University and has been in use for over 10 years. The ComputerLink system provides a common area that connects caregivers, patients, an academic university and public health care agencies [28]. The rationale behind using ComputerLink is to reduce patients' and caregivers' the sense of isolation and stigma for both patiens and caregivers that is often associated with medical conditions (such as HIV/Aids) [28]. The system can be described as a home-based computer network that offers a variety of support services to its users. These include an online medical encyclopaedia, interactive decision-support functionality, email services (to a nurse moderator) as well as an electronic bulletin board [29]. ComputerLink has modules designed for different target users: These include caregivers of Alzheimer patients, as well as HIV/Aids patients.

Computer terminals were installed in participants' home for the duration of the study (six months) and their usage patterns were analysed. The ComputerLink application is delivered primarily in text and users required on average one and a half hours of training [30]. The machines were connected to a public network via a telephone landline (a prerequisite for participation). Through ComputerLink they were given access to three services. The information service comprised of an online encyclopaedia. Communication services allowed users to seek professional advice from a moderating nurse, as well as post messages for support to a group notice board or forum. The third service was in the area of decision support: Here, users completed questions to gain an understanding of the problem domain and get clarification of available options [30]. In the pilot study reported in [31] the information service (i.e. the encyclopedia) was the most accessed area within the ComputerLink system. With the knowledge gained from this service, the authors saw that users became more active in their care. In a subsequent study reported in [30] it was found that of the three services available, the communication tools were the most widely utilised. This is due to the nature of communication itself, in that the information is constantly changing and users would repeatedly use this service. The system served predominantly as a medium for communication [30]. That is, ComputerLink provided a platform for participants to access both professional and peer support [30] in the privacy of their own homes. This communication was asynchronous and could be anonymous (important for stigma-related medical conditions). The actual support and communication is also stored on the system and can be retrieved when it is required [30].

When considering communication tools for people living with HIV/Aids, it is important to note that the disease has a different profile in each country of the world [32]. In the United States of America (where this system was used), homosexual males represent the largest group of HIV+ individuals [33] and this is very different to the HIV/Aids profile seen in South Africa (see Section 2.1.1). In a study conducted to investigate the usage of the ComputerLink project, 93% of the sample was male [30].

2.3.4 Mindset Health

Mindset Health is collaborative project between Mindset Network, Sentech and the South African Department of Health, with the aim of creating and dissemination educational resources for health education. The delivery media have been various information and communication technologies and include a satellite linkage to access information on demand. The focus of this content was initially in the area of HIV/Aids and TB. Mindset

Health targets public healthcare workers and patients [34], and has been deployed in over 300 healthcare facilities across the country [35]. In order to ensure that the informational content is accessible to as large a population as possible, the content is available in five South African languages [35]. The content is delivered in a combination of media: video, interactive computer applications and hardcopy printed material. The Mindset Health Channel offers both educational and entertainment content. This ranges from dramas and health talk shows and youth programmes, to documentaries, discussions, public service announcements and financial programmes [36].

Through focus groups of both health care workers and patients who had experience using Mindset Health terminals, it was found that the system was accepted as a health information dissemination tool, and the content was appropriate. The key concerns raised in the focus group discussions were the need to include the healthcare professionals in the content creation, as well as the need to train users with general computing skills [34].

In Figure 2-1, a Mindset Health terminal is deployed at a HIV/Aids clinic in Klerksdorp, a small town in the North West province, South Africa. The system includes a plastic hardware encasing that provides protection from both theft and accidental damage. A senior healthcare professional working at this facility found it particularly useful for preparation of presentations for provincial departmental meetings and keeping up to date with the latest developments in the HIV/Aids sector [37].

Figure 2-1: A Mindset Health terminal deployed at an HIV/Aids clinic in Klerksdorp, South Africa. Staff use the system to keep up to date with developments in the HIV/AIDS sector.

Another component of the Mindset Health system is large 84cm television sets, situated strategically in the waiting area of clinics [36]. In South African public health clinics, clients wait in these areas for between three minutes to three hours [36]. This component of the Mindset Health system is not interactive, but linear in nature. That is, all viewers experience the content in the same manner.

The benefits seen with the Mindset Health Channel highlight the need for such innovative technical solutions that provide informational support to individuals in the health sector. Different technologies offer different benefits, advantages and challenges in their usage. We turn now to another communication technology, virtual reality, one that has had little exposure in South Africa.

2.4 Virtual Reality

There are numerous definitions of virtual reality (VR) and virtual environments (VE), with most having the same basic foundation. That is, a VE can be viewed as any computer simulated environment that allows its users to enter the environment and to interact with objects and other users within the environment as they do in real life. Some authors incorporate specific hardware requirements into their definitions. All include the subjective response of 'being there' in the environment in some form. This is known as *presence* and is a

central area of concept in the field of VR research. For this work, we use the most basic definition given above.

The hardware requirements for a VR system vary and often depend on the available budget and resources. In developed countries VR is traditionally seen as a comprehensive, highly technical and specialised technology. A VE is a visually and auditory stimulating experience, and the different available hardware attempt to further stimulate the other senses. For example, haptic devices are used to provide the user with a sense of touch within the environment. Other equipment such as head-mounted displays, shutter glasses, goggles and tracking devices have been used successfully in improving the feeling of immersion experienced by users in a VR simulation.

In a developing country such as South Africa, it is important that resources are not wasted on unnecessary technologies and equipment. With this in mind, we were interested in using a low-cost alternative to the high-end VR systems more commonly available in Europe and America. A VE can be experienced on a consumer-grade desktop PC, with stereo headphones for audio. The average graphics card, standard with a mid-range desktop computer, is capable of rendering a visually rich VE.

2.4.1 Benefits of VR

Virtual reality is different to other information technologies, and it offers new benefits to its users. The main distinguishing aspect of VR is the notion of interactivity. Compared to say, a video or film production, the user is able to control the sequence of events and the information flow. Giving the user this control allows them to define their own personal VR experience which is tailored to their particular interests. The level of control required by the user also affects the level of participation. That is, the more the user is required to navigate through and interact with objects within the VE, the more involved they will be [4] .

An important aspect of the VR interface is that users draw from their pre-existing abilities, knowledge and expectations [38]. More traditional computer interfaces require a learned skill-set from their users. If we look at web interfaces for example, navigation is controlled by hyperlinks and the use of the 'forward' and 'back' links, commands that are unnatural to the novice user. The VR interface does not require these skills, since it maps more directly to users' natural interaction techniques with the real world. Jacob describes that VE navigation is improved since it "exploits the user's existing, natural 'navigational commands', such as positioning his or her head and eyes, turning his or her body, or walking toward something of interest. The result is a more natural user interface, because interacting with it is more like interacting with the rest of the world" [38].

Photo-realistic imagery is also used when designing VEs, to increase the approximation of reality in the general look and feel. There is an argument that this similarity reduces the amount of additional training required for successful usage and adoption of the system [4, 39, 40]. With the assumption that the target users for this research would have minimal (or no) prior computing experience, VR may be adopted more easily than other technologies.

2.5 Clinical Applications of Virtual Environments

We have seen a great deal of success in the use of VR technology in various clinical domains. The most successful and well documented of these has been in the treatment of anxiety disorders [41]. One behavioural therapy technique for treating such conditions involves gradual exposure of the patient to the stimuli that is producing the anxiety [42]. Patients are required to use visualisation techniques to imagine the varying levels of the anxiety-

producing stimuli. This is known as Systematic Desensitization [42]. The motivation for using VR as an alternative therapeutic medium for the treatment of behaviours is that it allows the individual to be placed in the environment that elicits the fear or trauma. This is particularly useful for patients that have difficulty imagining the scenes that cause the anxiety [42].

Successful applications that use Virtual Reality Therapy (VRT) have included VEs for the treatment of the fear of heights [43], flying [44], spiders [45], enclosed or confined spaces [46] public speaking [47] and driving [48]. Other successful VRT applications have been in the treatment of post-traumatic stress disorder and studies have been conducted with Vietnam veterans [49] and Iraq war military personnel [50], as well as survivors of the World Trade Centre bombings [51].

Ohsuga and Oyama see the main advantage of using VR technology in mental health care in that "interactivity with media may give the feeling of control to patients and thus provide a greater joy than passively watching television" [52]. Their therapeutic VR system is described later in Section 2.5.3). Additionally, in the motivation for using VR technology in a system providing support for cancer patients (discussed later in Section 2.5.2), Greene states that "interactive multimedia has the potential to help people more than ever by providing an individualized experience"[17]. Greene also mentions that "with the user in control, selecting content and interacting constantly with the program, the virtual experience is more meaningful than the one created by simply retrieving information" [17].

We now look at four clinical applications that have exploited the advantages of the VR medium.

2.5.1 Naledi3d

Dave Lockwood of Naledi3d, the only company to market VR applications in South Africa, feels that VR is an under-utilised medium, but one that has great potential in a developing country context. Because it is graphically driven it can overcome literacy barriers [53] that other traditional communication mediums such as brochures face. Another important benefit identified by Lockwood is that a VE provides a safe, non-threatening environment [53], and this is particularly relevant for a support intervention aimed at people living with HIV/Aids. Naledi3d have successfully created a number of VR applications in the areas of education and training. The focus of their applications includes industrial training and safety awareness, educational, heritage and culture, and infrastructure development (www.naledi3d.com). One of these was a VR simulation for educators working in Ethiopia. The content was HIV/Aids awareness and with four environments (a clinic, home, library and classroom), the user is able to access HIV/Aids information such as facts and statistics, myths, nutrition and prevention. Screenshots of these environments can be seen below, in Figure 2-2.

Figure 2-2: Naledi 3D created four educational VEs targeted at educators in Ethiopia. The system was used to empower users and increase awareness of HIV/Aids. The topics presented in the four rooms included statistics, myths, nutrition and prevention.

2.5.2 Virtual Environments for Providing Cancer Information

Greene *et al.* assess the possibility of using virtual reality to enhance the quality of life in patients with cancer [17]. The authors created three VEs (known in their literature as CD-ROMs), each assessing different aspects of living with a cancer diagnosis. The first of these environments (The Breast Cancer Lighthouse) used a beach setting in which the user was able to access both personal stories (from other virtual characters) and medical information on the island garden. The second virtual environment (the Easing Cancer Pain) was designed to provide support to patients in dealing with the physical pain associated with cancer. The chosen setting for this environment was a natural retreat consisting of a forest campfire, lake and dunes, each providing a different area of expertise. The final environment was an educational theme park in which users could choose from four virtual kiosks to learn more about nutrition, sun exposure, physical exercise and exposure to smoke and second hand smoke. Screenshots taken from these three environments are shown in Figure 2-3 below.

Figure 2-3: Three virtual environments were created to provide support to cancer patients. Users can access personal stories and medical information in the 'Breast Cancer Lighthouse' environment (above left), can learn methods to deal with the negative symptoms of the disease in the 'Easing Cancer Pain' environment (above center) and learn about cancer prevention techniques in the 'Cancer Prevention Park' environment (above right). Source [17].

Greene presents a thorough detailed list comparing a VE that provides informational support, to other conventional health information dissemination products (such as instructional patient information videos, brochures, etc.). It was found that VEs are more suited for such an intervention strategy than other media forms [17].

Greene identified key benefits that should be considered when creating VEs for targeted at individuals faced with life crises such as a chronic illness diagnoses [17]: Through the use of

audio, narration, graphics and animations, a VE can be designed with a particular mood or feeling in mind. For therapeutic VEs, this mood should be warm, comfortable and inviting, and should aim to encourage user involvement. When creating the dialogue for the virtual characters, it is beneficial to address the user directly (in terms of 'you') as it would assist in creating that personal experience. The tone of the voice clips should also be caring and sensitive to the user's current situation [17].

2.5.3 Bedside Wellness System

Since 1993, the National Cancer Centre Hospital in Japan has been developing VR applications to improve cancer treatment and provide support to patients in the fight against cancer [54]. Their focus has been on the use of VR to provide palliative care to their patients. This type of care involves the reduction of pain and other symptoms, and also addresses psychological, social and spiritual problems. They have a variety of VR projects, ranging from surgical simulations, medical image diagnoses, to medical education [54]. The VR application that was investigated for this research was their psycho-oncological VR therapy project, known as the Bedside Wellness System.

The goal of the Bedside Wellness System is to improve patients' quality of life and the target users are cancer patients. Pain is a very difficult and common symptom experienced by cancer patients. This debilitating pain can cause mental stress, fatigue and depression. It was hoped that through the VR system, some of the anxiety and stress experienced by patients, could be reduced [55]. The Bedside Wellness System is a sensory rich application, with stimulation of patients' senses of sight, sound, touch and smell. The system comprises of the following interlinked systems:

- A triple LCD screen
- Stereo sound output through either headphones or speakers
- A walking system for the bedridden users
- A scent system (related to the content)
- A system for monitoring vital signs (heart rates, blood pressure and respiration) [55]

See Figure 2-4 below for the physical setup of the Bedside Wellness System. The comprehensive hardware components of the system encourage the users to feel highly immersed within the environment.

The user is able to experience a walk-through of one of three virtual environments. They are a typical park, a plateau, and an avenue of cherry trees [55]. In a study looking at the effect of experiencing the Bedside Wellness System, Kimura *et al.* found that the VE was successful at reducing stress and fatigue, and encouraged relaxation in the participants [56]. From the vitals monitoring system, it was found that participants' heart rates decreased moderately during the VR experience, and patients' pain thresholds increased [56]. The Bedside Wellness System has been found to be an effective therapeutic tool for use in palliative care.

The realism of the environments was realized through the use of actual photographs used in texturing the environment, and also though the use of appropriate scents and the soundtrack. Within the VE, the user does not control the navigation (it is a standardized walk through), and this aspect is an area identified for future work by the researchers at National Cancer Centre Hospital.

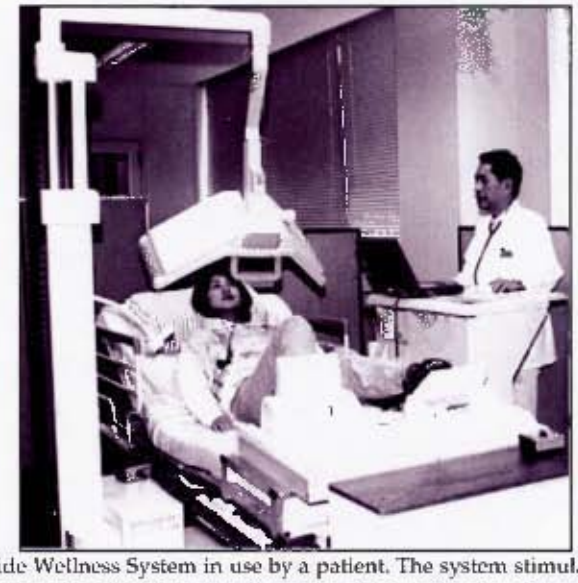


Figure 2-4: The Bedside Wellness System in use by a patient. The system stimulates patients' senses of sight, sound, touch and smell while they experience one of three virtual environments.

2.5.4 Virtual Support Group for HIV+ People

As the first study in our research program (this work is the third), Hamza and her colleagues created a VE to research the impact of experiencing a virtual support group with HIV+ characters [57]. It was tested with seven HIV+ people in the Cape Town area in 2004. In their study, Hamza *et al.* created an environment consisting of a campfire in a forest; a warm setting that helped to create the tranquil and relaxed environment required of a therapeutic intervention. Each of the virtual characters attending the support group had personal narratives and these were categorised into three distinct sections: *Diagnosis, Adjusting to HIV* and *Living with HIV* [57]. An important lesson learnt from this research related to the first component of the characters' narratives – the diagnosis. Receiving an HIV+ diagnosis is a very stressful, personal, life-changing event and listening to other peoples' stories about this aspect of living with HIV was found to be traumatic for many participants. This highlights the importance of using encouraging and motivating narratives presented in such an application. The VE was a successful therapeutic intervention, and they found that VR could provide emotional support to its targeted end users [57]. The results obtained indicated that while their participants identified the importance of the virtual support groups, they preferred and saw more benefits in, a real support group. The VE reinforced the benefits provided by real support groups [57]. Figure 2-5 below shows the four virtual actors meeting around the campfire in a forest environment.

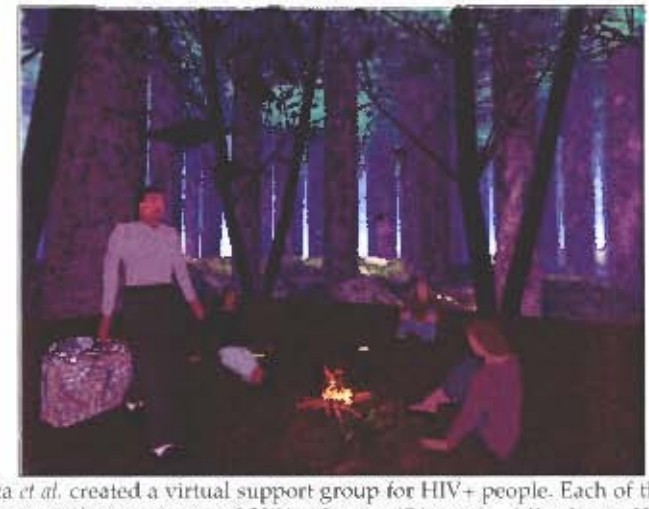


Figure 2-5: Hamza *et al.* created a virtual support group for HIV+ people. Each of the actors had three narratives relating to different aspects of HIV infection (*Diagnosis*, *Adjusting to HIV* and *Living with HIV*). The user could access these different narratives.

2.6 Nutrition Support for HIV+ People

The relationship between nutritional status and HIV infection is widely documented [9, 58-60]. Figure 2-6, taken from the South African government's national guidelines on nutrition for people infected with HIV and other chronic diseases [58], shows the cyclic relationship between these two concepts.

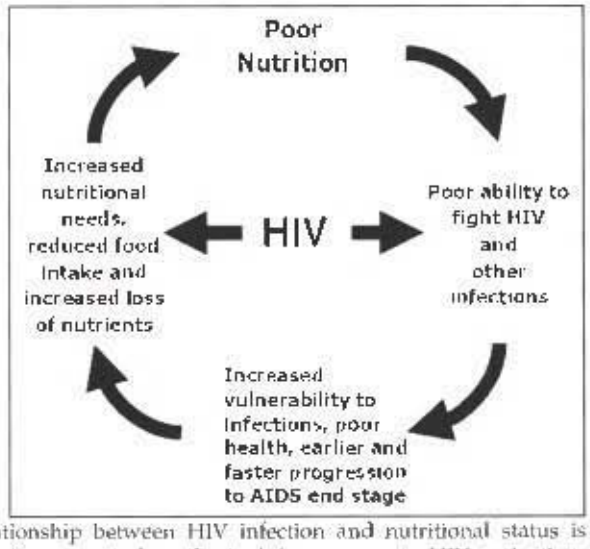


Figure 2-6: The relationship between HIV infection and nutritional status is cyclic in nature. As nutritional status declines, so to does the body's response to HIV and other associated infections. Source: (Kennedy 2001)

On the left in Figure 2-6 one sees that HIV causes an increase in nutritional needs since the immune system is working to fight off the different infections associated with the HI virus. HIV infection also causes a reduction in food intake — a loss of appetite could be the result of psychological problems (such as depression, fear and anxiety). Additionally, certain opportunistic infections suppress individuals' appetites, and some infections make it physically difficult to eat (such as mouth and throat infections associated with HIV/Aids). Moreover, HIV infection causes an increase in nutrient loss from the body through diarrhoea

and other opportunistic infections, and deterioration in the stomach lining causing difficulties in absorbing and digesting nutrients from food. These factors all contribute towards a poor nutritional status for an HIV-positive person (top in Figure 2-6).Figure 2-6 This in turn causes a reduction in the functioning of the immune system (right in Figure 2-6), which consequently makes the individual more vulnerable to other infections and poor health (bottom in Figure 2-6) [9, 58, 60].

Conversely, good nutrition for HIV+ people can provide benefits in a number of different ways. These include the replenishment of energy and nutrients lost during HIV and other opportunistic infections, the prevention of muscle loss, the promotion of a sense of well-being in the individual, and may help to delay the progress from HIV to Aids [9, 58, 60].

The South African government incorporates nutritional support and care in their comprehensive care and treatment programme for people infected with HIV/Aids. The nutritional component of the national programme includes food supplies, counselling and information on healthy eating habits, safe food preparations as well as coping skills for dealing with HIV/Aids infection [61].

In their literature review of nutritional care and support in sub-Saharan Africa, Piwoz and Preble identify key components of nutritional programs for people living with HIV/Aids [9]. According to the review, programs include at least one of the following:

1. Nutrition education and counselling services. The aims of such programmes are to increase consumption of specific, recommended food items. One component of nutrition counselling is the provision of dietary-based recommendations for commonly experienced HIV/Aids-related conditions (such as chronic weight loss and diarrhea).

2. Interventions aimed at water, hygiene and food safety to prevent diarrhoea (a commonly experienced infection for HIV-positive individuals), as well as other food-borne illnesses.

3. The provision of actual food items (prepared meals and food baskets) to households affected by HIV/Aids.

The primary aim of our research is to investigate the use of VR as a communication medium for informational support to end-users of the system. Thus, the first two identified components were included in this research. The third component of the provision of food items to affected individuals however, is beyond the scope of this research.

Piwoz and Preble also identify desired outcomes or objectives for nutritional support programs for PLWHA. Those that are relevant to the VR medium are listed below [9]:

1. Nutrition counselling involves basic education of good nutrition (including food groups concepts), and suggestions of good nutritional practices [60]. A desired outcome for a program providing nutritional counseling is the development of good eating habits.

2. Another objective of nutrition counselling is an increase in the daily consumption of key vitamins and micronutrients. To increase immune system functioning, PLWHA require additional micronutrients that are difficult to obtain from dietary intake [9]. A desired outcome would be the inclusion of recommended vitamin in the diet of an individual.

3. Stomach complaints are a widespread side-effect of HIV infection and diarrhoea is one of the most commonly reported infections. This affects food consumption and

dietary intake. Nutritional recommendations regarding the prevention of such health problems are important and inclusion of these recommendations in an individual's diet would be a desirable.

4. All literature in this area stresses the importance of clean and safe water for PLWHA [9, 58, 60, 62]. If an HIV+ person suffers from diarrhea, the body requires additional replenishment of water. Programs should emphasize this importance and if successfully delivered, an individual would increase their daily water consumption.

5. With a suppressed immune system, PLWHA are more vulnerable to other infections, including food-borne illnesses. All literature in this area includes recommendations for HIV+ people to safely and correctly handle, prepare and store food and water.

For this research, we categorise the above five outcomes into two main areas, namely *Food Safety Knowledge* and HIV-Related *Dietary Quality*. The latter group comprised of four components: *Food Intake, Water Intake, Vitamin Intake* and *Specific Dietary Behaviours* (recommendation for the prevention and management of HIV-related infections).

2.7 Evaluation Strategies for Nutritional Support Programs

Having identified the components that are suitable for a VR intervention program for nutritional support as well as the desired outcomes, we now identify the appropriate methodologies for evaluating effective delivery in a VE of the two components. The first is dietary assessment methodologies and the second are assessment methodologies for hygiene and food safety interventions.

2.7.1 Dietary Assessment Methodologies

In order to investigate the effectiveness of an intervention that provides nutrition counselling and education, we turn to dietary assessment methodologies. That is, if information is presented to an individual, the success of that delivery should reflect in a change in their dietary behaviour. The relationship between nutrition knowledge and actual dietary behaviour is debatable; some studies have found a positive correlation between the two concepts, while others have not [63, 64]. For this reason, it is best to examine actual dietary behaviour when assessing the possible impact of a nutrition counselling and educational intervention. Robson and her colleagues provide an excellent comparison of the most commonly used methods for assessing diet among individuals [65].

Food frequency questionnaires (FFQ) are structured questionnaires in which participants are asked to estimate the frequency of specific food items consumed over a set period of time. The amount of food items included in a FFQ depends on the research study, and they range from a small subset of items to lengthy comprehensive item lists. This method of dietary assessment relies heavily on participants' memory and this is problematic when a FFQ comprising of a large number of food items is used. Another difficulty is that the food items contained in the list need to be appropriate to the local population and environment. For example, a FFQ designed in North America would not be suited to a South African population group [65, 66].

The diet history technique is another dietary assessment methodology, and uses a semi-structured interview format. Participants are asked to describe their regular, habitual, diet. Estimates are generally also used to describe portion sizes and the general reporting period

is usually one week. This method is quite time-consuming, and thus requires dedicated attention from all participants for the interview duration [65, 67].

The third dietary assessment methodology is the 24 hour recall technique. As the name implies, participants are asked to describe the exact contents of their previous day's food and drink consumption. As with the FFQs, this assessment technique relies heavily on participants' memory. The largest problem with this technique however is that only one day is examined and it therefore, cannot be representative of participants' dietary behaviour in general [65, 67].

Because of the reliance on participants' memories for both the FFQ and 24 hour recall methodologies, these techniques are problematic for the intended target population of this research. HIV infection can cause Aids Dementia Complex, with one symptom being memory loss [68]. For our research, food records or food diaries were the most appropriate dietary data collection methodology. Here, participants are asked to record every item consumed or drank on a number of specific days. Since the supplied diary or recording book is easily available to the participant during the actual day of recording, more accurate data capture is possible. Individuals keeping food diaries can also be asked to record sizes of items consumed. This can either be weighed whereby measuring scales are supplied along with the food diary, or estimated using household measures (such as cups and spoons), units (such as slices or number of eggs) or fractions of packaged foods (e.g. half a tin of canned peas) [65, 67]. Food diaries can be administered over different numbers of days (the most common alternatives are three, four and seven days). To increase the compliance with record keeping, the 3-day derivative was chosen [65].

Once data has been collected using any of these above techniques, an analysis is required. A common general methodology for doing this is to categorize consumed food items into a number of different food groups, and to analyse the diet in terms of frequencies and occurrences within each of the groups [67, 69, 70].

The Healthy Eating Index (HEI) was developed by the US Department of Agriculture's Center for Nutrition Policy and Promotion to assess the overall dietary quality of the American population [71, 72]. The HEI comprises ten separate components; each of which is based on varying aspects of a healthy diet. A subject can score between 0 and 10 for each of the ten components, resulting in a maximum score of 100 for the HEI. Components one to five are related directly to the five different food groups (grains, vegetables, fruits, milk and meat). Components six to nine are related to total fat consumption, saturated fat consumption, cholesterol intake and sodium intake respectively. Finally, component ten is a measure of the variety found in a person's diet.

Due to a lack of existing tools and measures, Kim *et al* designed an alternative dietary scale to assess differences in diets of individuals living in different countries. In a study examining typical diets in the United States (n=9768) and China (n=8352), the Diet Quality Index-International (DQI-I) scale was found to be an effective tool for cross-country comparison of diet quality [73]. Like the HEI, participants are given a score between 0 and 100. Those with a higher aggregate score have a healthier diet. There are four distinct components of the DQI-I:

- **Variety (0-20 points):** This component was further broken down into:
    - Overall food group variety (0-15 points): A maximum score of 15 is given if there are five different food groups present in the daily intake.
    - Within food group variety (0-5 points): A maximum score of 5 is given if there is at least 3 different sources of protein present in the daily intake.

- **Adequacy (0 to 40 points):** Depending on the quantities of items consumed from each of the following groups, a score between 0 and 5 was given.
    - Vegetables, fruits, grains, fiber, protein, iron, calcium and vitamin C.

- **Moderation (0 to 30 points):** Depending on the proportion of the following negative items included in a diet, a score between 0 and 6 was given.
    - Total fat, saturated fats, cholesterol, sodium, empty calorie foods.

- **Overall balance (0 to 10 points):**
    - Macronutrient ratio (0 to 6) and fatty acid ratio (0 to 4).

2.7.2 Hygiene and Food Safety Assessment Methodologies

The second component of nutritional support programs for people affected with HIV/Aids that was identified for this research, are interventions aimed at water, hygiene and food safety. An aim for such interventions is the prevention of food-borne illnesses commonly experienced by HIV-positive people. Like the dietary assessment techniques discussed in Section 2.7.1, one looks at behaviour change in the specific safety areas. Data on food safety behaviours is captured using one of three techniques: Questionnaire and interview surveys, focus group discussions and observation studies [74].

Observation studies have been reported to collect the most reliable data since observations are made on actual behaviours. However, this is an extremely time-consuming methodology and consequently, very expensive [74]. Focus group discussions are useful to identify a population groups' current understanding of food safety knowledge, but are not useful for measurement of specific individual's knowledge base. Questionnaires are thus the most used technique to measure individual, home-based, food safety practises.

However, questionnaires in the field of food safety behaviours, usually focus on self-reported behaviours, and many studies have found major discrepancies between data collected from such questionnaires, and actual observed food safety practises [74-76]. In particular, participants show bias towards behaviours that they perceive as "good" hygienic practises [77-79] in [74]. Due to these factors and resource constraints, knowledge-based questionnaires were found to be the most useful measure for this research [80].

Medeiros and her colleagues designed and developed a food safety knowledge questionnaire based on food-handling guidelines (which had been developed by a national panel of food safety experts) [80]. The designed questionnaire could be used to assess participants' knowledge on the subject matter prior to an educational intervention, and to evaluate the effectiveness of an education-based intervention program that teaches correct, hygienic food handling behaviours [80]. More information on this questionnaire is presented later in Section 4.5.4.

2.8 Chapter Summary

With South Africa having the largest population of HIV+ individuals in the world and the benefits of social support for HIV infected individuals identified, there is a need for social support systems and interventions that extend the capacity of an over-stretched public health sector. Different information and communication technologies (ICTs) that have been used successfully in an attempt to deliver such social support services were discussed. Four of these that had influence in the VE designed for this research were presented. The Comprehensive Health Enhancement Support System (CHESS) has been used successfully

in the United States of America for people infected with HIV/Aids and other chronic diseases. The second is Mindset Health, a local ICT provider of HIV/Aids information who has deployed computer systems at over 300 health care facilities in South Africa. One challenge in this type of technologies is the learning time required for effective usage of computer applications and a requirement of general computing experience. We argue that VR can assist with this due to the close approximation of a VE to actual reality in terms of its interactions. A number of VR applications, used in the clinical care, were presented. We conclude this chapter with a summary of the HIV information content to be communicated to our target audience using the VR medium. In the next chapter, we describe the VE that was designed and created for this research.

Chapter 3

VE Design and Implementation

In order to answer the hypotheses underlying this research, a VE was created. In this chapter, we detail the process that was followed in creating the environment; starting from the initial design concepts and the design criteria used, to the end product that was used in the experiments.

3.1 Design Decisions

At the start of a VE design, it is important to have a clear understanding of the mood, basic structure and general look of the environment and the virtual characters within it.

3.1.1 The House

It was our intention to create a warm, accommodating and familiar environment, one in which users would feel comfortable. A home was chosen with this purpose in mind. We decided to have the VE take place during the day, with sunny blue skies. This contributed towards the positive mood of the environment, which was reinforced by the agents and their supportive narratives.

HIV support encompasses many different areas of knowledge. Because of this, we wanted the VE to be modular in nature. That way, it would be possible to incorporate further components into the VE at a later point in time. By using a house we were able to modularise the VE by using different rooms for different areas of HIV knowledge and support. The information provided in each room could then be specific to that room. For example, safe sex education could be presented in the bedroom and relaxation techniques could be presented in the garden. And finally, the use of a modular house also provided an easy separation of the VE content into distinct areas. This separation created logical scenes, which assisted when creating the storyboard (discussed later in Section 3.2).

3.1.2 Background Sounds

Adding audio to a VE has numerous benefits and the importance of this component in VEs is well known [81]. It has been shown to increase a user's sense of presence [82, 83]. This is the sense of 'being' in the VE [84, 85] rather than the user's actual physical place, in front of a computer screen). When paired with the visual cues of a VE, sound also assists the user in

localising objects within the environment [86], helps with the spatial representation of the VE [86, 87] and increases the sense of realism [81].

There are two types of sounds that can be used in a VE soundtrack – ambient sounds and sound events (known as Foley effects) [83]. Sound events are predictable, user triggered sound such as footsteps. Ambient or background sounds such as wind blowing are used to set a mood or atmosphere [83]. The house in the VE was set in a neighbourhood. We thus included ambient sounds of barking dogs, playing children and distant traffic sounds. Sound events of running tap water and other kitchen sound clips were included.

3.1.3 South African Virtual Characters

The South African population is very diverse, and we wanted the characters in the VE to reflect this diversity in terms of accents, gender, age and race. This also assisted with the familiarity we wanted users to experience. With this in mind, final year drama students from the University of Cape Town's drama department were recruited to provide voice recordings for an African man, a coloured woman and a white man (for the lounge scene), as well as an African woman (for kitchen scene character).

There are countless 3D models available on the Internet for download, but they are generally more suited towards computer games and/or western culture. Additionally, the animations on these downloaded characters are generally inappropriate for therapeutic interventions. Effort was thus made to create virtual agents that together, incorporate the diversity that is the South African population.

3.1.4 Nutritional Support Presented in the Kitchen

In Section 2.6 we identified five areas in nutritional support. They are:

1. *Food Intake*
2. *Vitamin Intake*
3. *Water Intake*
4. *Preventative Dietary Behaviours*
5. *Food Safety*

The food pyramid is one of the most widely used and recognized figure in the area of nutrition educational campaigns. In Figure 3-1 below (from the South African Department of Agriculture), the positioning and size of each section of the pyramid is used to categorise the types and quantities of foods that should be present in a healthy diet [88].

Figure 3-1: The Food Pyramid as presented in a pamphlet on HIV/Aids and Nutrition by the National Department of Agriculture in South Africa (2002) [88]. A healthy diet includes items from all groups within the pyramid, with the positioning relating to the quantity of each item.

In Figure 3-2 below, in the national guidelines on nutrition for people living with TB, HIV/Aids and other chronic debilitating conditions [58], the Department of Health recommend a variety of food groups and items.

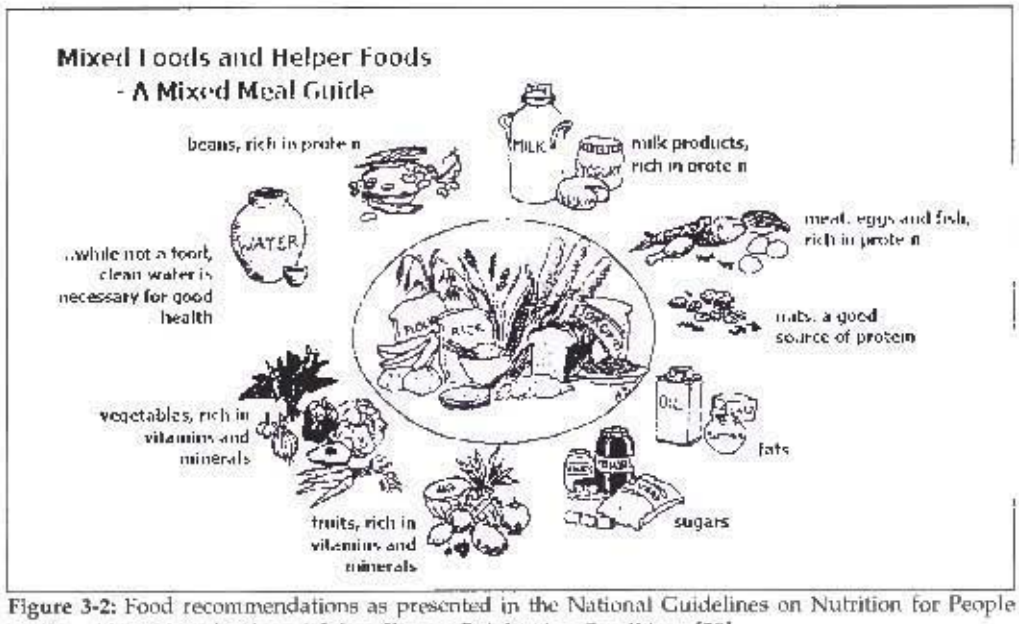


Figure 3-2: Food recommendations as presented in the National Guidelines on Nutrition for People Living with TB, HIV/Aids and Other Chronic Debilitating Conditions [58]

There are many similarities in these campaigns and others: the most obvious of which is the categorising of food items into groups. We wanted the groups to fit naturally into the kitchen setting, and thus chose wooden bowls to represent a food group and to place between three and seven food items specific to that group into one of nine wooden bowls. Names for food groups were visible on the exterior of each bowl. We wanted the users to be

familiar with the food group names, and thus did not use the more scientifically correct terminology. For example, the 'Carbohydrate' food group was labelled 'Energy'. Also, a colour was associated with each food group, depending on whether the food groups contained items that HIV+ individuals should increase or reduce in their daily dietary intake. The chosen colours were green and red respectively.

It was originally planned to have a separate vitamin cupboard placed on the wall in the kitchen. This cupboard would have three shelves, and different vitamins would be positioned on these shelves. However, it was decided that it was unnecessary additional work. It simplified the modelling, scripting and design process to include it with the food consumption area. Also, vitamins are naturally related to food intake. Effort was made to promote the cheapest way of getting the six required vitamins.

The common recommendation of two litres of water per day is particularly important for HIV+ individuals. Certain activities reduce the amount of water in a person's body and nutritional programs for HIV+ people need to include these recommendations. Emphasis should also be made on water safety, to reduce the risk of unnecessary additional infections.

Preventative measures are dietary recommendations that HIV+ individuals can do to reduce the risk of, and even prevent certain common ailments. Stomach infections are particularly problematic with HIV infection and this affects the body's ability to absorb nutrients from food eaten. It can also affect food intake which has numerous problems. Eating three specific food items regularly can assist with the protection of the stomach.

The importance of practising food safety in the preparation, storage and usage of food is particularly important for HIV+ individuals. Incorrect practises can result in unnecessary, additional infections.

3.1.5 Emotional Support Presented in the Lounge

Since the VE was designed to be a therapeutic intervention, we wanted to provide some level of emotional support to the end users. As discussed in Section 2.5.4, in a study leading up to this research, Hamza and her colleagues found a positive impact in HIV+ participants who experienced a VE support group [57]. Because of this, we chose to include a motivational support group where similar personal narratives to those used in the Hamza study were presented. These narratives were fictional and were provided by Ms Mignon Coetzee. Ms Coetzee, a clinical psychologist and HIV counsellor, used her experiences with HIV+ clients as basis for the support group narratives. The narratives were written as short, introductory conversations between HIV+ individuals. The tone used was one of motivation, encouragement and hope. The narratives presented in the Hamza study were divided into three components (*Diagnosis, Adjusting to HIV* and *Living with HIV*) and the user could access each component of interest [57]. Many participants found it traumatic being reminded about the *Diagnosis*, so we chose not to focus heavily on this area for our narratives. The lounge scene was used to set the mood of the VE and to encourage the HIV+ user to feel comfortable and see other people sitting around, talking and being hopeful and honest about their experiences. The virtual support group served as an introductory session (to both the environment and virtual characters) for the user.

3.2 Creating a Storyboard

Once the content had been selected for inclusion into the VE, we set about creating a storyboard. Building a VE often requires the expertise of many different individuals from multiple disciplines. Because of this, a common document such as a storyboard is necessary

for the communication of ideas between these individuals. It also guides the design and implementation process as a whole.

Storyboards have their origin in film production. Due to the many similarities between VR and the film media, it seemed a natural tendency to use a similar tool in VE design. However, there are some inherent issues unique to VR that impact directly on the use of storyboards and the functionality they provide. The most significant of these is the non-linearity of VR in general. In this medium, the user is completely in control over what content is experienced at any point during the VE, and input from the user is used to drive the experience. Storyboards from the film industry are linear in terms of event sequences, and this is not the case for VR. The order is determined during the experience itself, and can be unique to each user driving the VE.

The storyboard was used primarily for communications with graphic artists and modellers. These individuals were not interested in the navigational areas or the general event flow of the environment, but rather on the static areas of the VE that required modelling and texturing. As can be expected, it was found that textual descriptions alone could not accurately convey the type of images and scenery required. A combination of both text and graphics were required. Microsoft PowerPoint was used to create a document for this purpose, since it is a commonly used tool and freely available to research students at the University of Cape Town. MS Powerpoint also provides an easy integration of text and images.

The storyboard included information on the following areas.

- Floor plan of the house
- Outside view of the house (including the garden)
- Road and neighbourhood
- Lounge (including the furniture required and décor)
- Bathroom
- Bedroom
- Kitchen

For each area an overview diagram was provided. This was a basic outline diagram for the room / area and assisted with object placement and dimensions. Reference material was also provided. This material consisted of photographs of similar areas in Cape Town suburbs, as well as downloaded images from the Internet. In Figure 3-3 below the slide that was used to describe the lounge modelling requirements is given. The complete storyboard document is presented in Appendix A1.

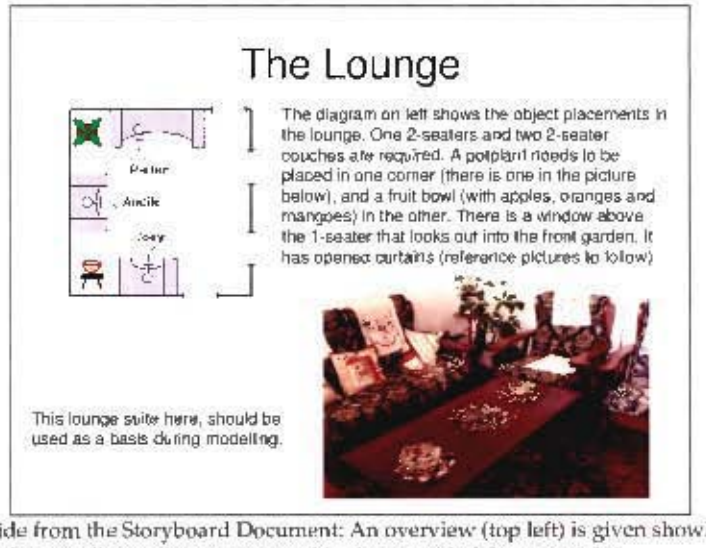


Figure 3-3: A slide from the Storyboard Document: An overview (top left) is given showing object placement and photo-realistic reference material is also provided (bottom right).

3.3 Creating the Event Flow Document

Our method for dealing with the non-linearity aspect of VR is to group all related interactions together. Since we were using a house as the actual setting, each room provided an easy separation for these interactions. The interactions between the user and characters in each of the rooms were grouped together, and called a scene. In the more complex rooms (such as the kitchen), the scene was split into smaller, more contained sub-scenes and transitions between the sub-scenes were clearly defined.

HTML pages were used to manage the scripts and possible event flow between the different areas in the environment. A scene within the VE had a corresponding HTML page. In the same manner that a VE user can walk into a different room and hence experience a different scene, hyperlinks provided an easy way to navigate within the document structure. The set of HTML pages making up the Event Flow Document is presented in Appendix A2.

We identified four distinct scenes to include in the VE:

3.3.1 Scene 1: Outside the House

We assumed that our end-users would not be completely familiar with input devices. Because of this, we wanted users to initiate the initial conversations with the virtual characters and we wanted them to do this, when they were comfortable to do so. For this reason, we planned for the user to start their VR experience outside the virtual house. The first scene was thus identified as the user on a virtual street in a suburban neighbourhood, positioned outside the house.

3.3.2 Scene 2: Front Door

We wanted our users to feel welcome in the home, and thus planned to include a virtual character that could act as a guide / host through-out the VE. This agent was named *Andile*, and its initial position was outside the house, at the front door. The second scene begins when the user approaches *Andile* and triggers a personal introduction and an introduction to

the house in general. After these introductions, the user is encouraged to join *Andile* in the house. The second scene ends when the user follows him into the house.

3.3.3 Scene 3: Lounge

The third scene begins when the user walks into the lounge of the house. *Andile* joins two other agents (*Pieter* and *Joey*) who are participating in a virtual support group, discussing their personal experiences of HIV infection. The conversation flow between the three agents is linear in that one conversation piece occurs and the three agents participate in a prescribed sequence. However, if the user left the room during the discussion, the individual conversation piece would finish, and the conversation would only resume when the user returned to the lounge. Since this room was used to introduce the user, no major interaction was required from the user. At the end of the short support group conversations, the dialogue turns to the area of good nutritional practises, and the agents encourage the user to move into the next room / scene.

3.3.4 Scene 4: Kitchen

The fourth scene starts when the user crosses a trigger point positioned in the kitchen door. The user meets another agent, *Sandi*, who is a knowledgeable older woman and acts as the guide in this main room. She begins a scene with a personal introduction as well as a overview of what can be experienced in the room. Due to the quantity of information presented in the kitchen, the room was divided into two smaller, more contained sections. These were Food Groups (scene 4A) and Cleanliness & Hygiene (scene 4B). The user is encouraged to move to one of these two areas, and can also move freely between the two. Each of the areas in the kitchen has a proximity trigger associated with it. When the user is close enough to either of these triggers, Sandi starts to walk towards the area.

3.3.5 Scene 4A: Food Groups (food consumption and vitamin consumption)

As can be seen in Figure 3-4, the food groups included were *Fats & Oils*, *Sugars*, *Herbs*, *Milk*, *Energy*, *Vitamins*, *Proteins*, *Fruits* and *Vegetables*. Although some of the groups are not traditional food groups (e.g. vitamins and herbs), they were included due to their importance for HIV infection.

Figure 3-4: The nine food groups, categorized into nine colour-coded wooden bowls. The bowls with green labels contain food items that are extremely good for HIV+ people. The bowls with red labels contain food items that are not.

The food bowls were placed on a wooden table, or on a shelf above the table. The user was able to select one of the wooden bowls, and this prompted the kitchen character, Sandi, to unpack the items in the group and provide additional group-specific information to the user. These sub-scenes (for each of the groups) also presented nine specific scenes and were hence also HTML pages. They were linear and self-contained, in that upon request the user would listen to the entire food group description. Each of these nine sub-scenes had the same following structure:

- The user chooses the bowl.
- From her start position in the corner, in front of the table, Sandi walks towards the chosen bowl and picks it up.
- Sandi unpacks each item onto the table top and lists them while she is doing so.
- Sandi describes the food items positioned on the table and other important facts about the food group.
- Sandi packs up the items into the bowl.
- Sandi returns the bowl to its position on the shelf / table.
- Sandi returns to the start position.

In Figure 3-5, Sandi is in the middle of the sequence for the *Milk* food group. She has unpacked the food items onto the table, and is describing their importance. Following this, she will return the items to the bowl held in her right arm, and return the *Milk* bowl to its position on the shelf.

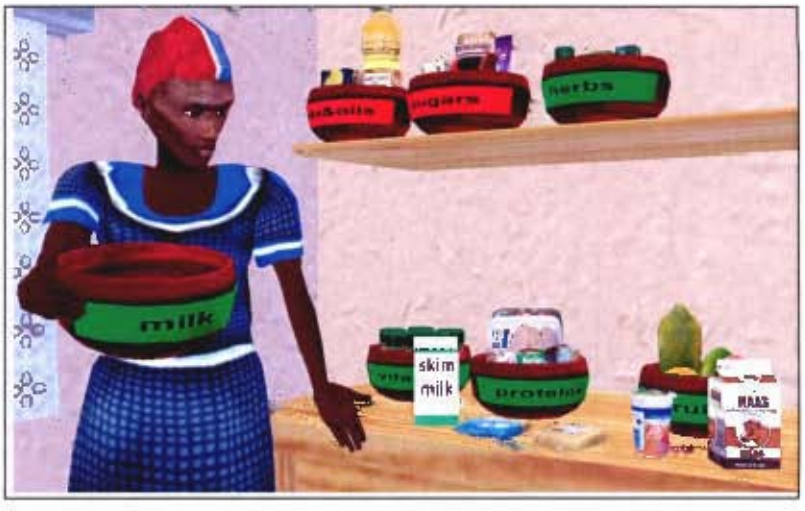


Figure 3-5: Sandi is half way through the *Milk* sub-scene. The items in the bowl have been unpacked, placed on the table top and Sandi is discussing the importance of the *Milk* food group.

3.3.6 Scene 4B: Cleanliness & Hygiene (water consumption, preventative measures and food safety)

The area in the kitchen that was dedicated to cleanliness and hygiene was the sink area. This was on the opposite side of the room to Scene 4A (Food Groups), to allow for a clear separation of the two scenes. A woven box was positioned next to the sink and contained all the props required for demonstrating the water consumption, preventative measures and food safety sub-areas. Like the nine food groups in Scene 4A contained nine sub-scenes, Scene 4B had three sub-scenes: *Clean Food* (food safety), *Clean Stomach* (preventative measures) and *Clean Water* (water intake). Motivation for structuring this area into these three specific sub-areas arose from readings in Positive Health [59]. Note that although the

area for water consumption was named *Clean Water*, the focus of the narratives was focused on both safe water practises as well as the correct consumption of this safe water. The user was able to access the three sub-scenes by selected one of three pictured tiles, positioned above the sink (see Figure 3-6).

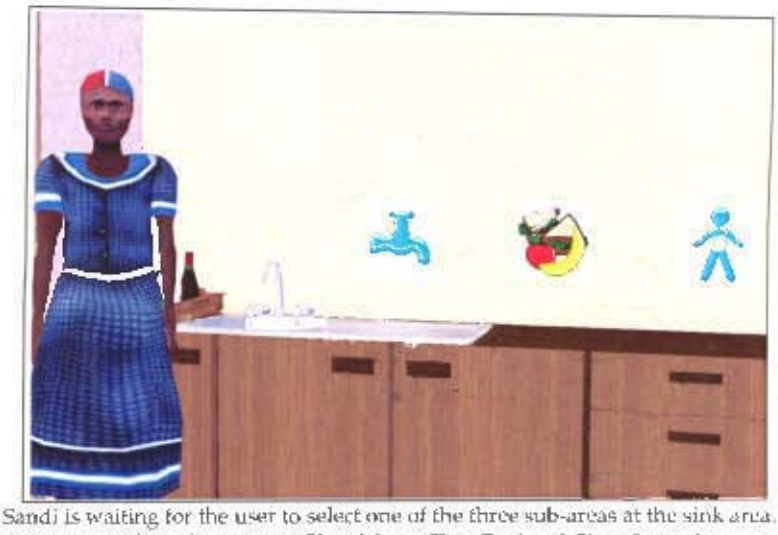


Figure 3-6: Sandi is waiting for the user to select one of the three sub-areas at the sink area. From left to right, the options available to the user are *Clean Water*, *Clean Food* and *Clean Stomach*.

3.4 Creating the Static Environment

The physical structure of the virtual house, its surrounding area and all props used in the VE were created using Maya 5.0, a 3D modelling and animation software package. Since we wanted to create an environment that users would find familiar, numerous field trips were conducted into areas surrounding Cape Town. On these trips, photographs were taken and later used for reference material in the visual storyboard. Textures are an integral element of a VE and for this environment original photographs, downloaded images and original texture files were used. Adobe Photoshop 7 was used extensively when creating all the textures. The textures were saved as Targa (.tga) files and placed on the 3D models in Maya.

3.4.1 The Skybox

Table Mountain is a familiar site in many suburbs in Cape Town and we wanted the VE to include this environmental feature. Creating a skybox in an urban area is a challenging endeavour. Suburbs generally include neighbouring houses and taking a panoramic photograph in this type of area results in an image with many foreground objects. These photographs are difficult to use if converted into a skybox since the foreground objects become distorted in shape. After unsuccessful attempts at creating a panoramic photograph in a suburban area, we conducted a field trip to Phillipi (farming area 15km from Cape Town). Here, we were able to take a photograph in the middle of an open field. This setting ensured that the foreground was void of any objects and could thus be used successfully as a skybox for the VE. The panoramic photograph used is shown in Figure 3-7.

Figure 3-7: The panoramic photograph used for the VE skybox. The back of Table Mountain is clearly visible in the landscape.

3.4.2 The House

The house was modelled on a typical South African council house. It was originally planned to model the house on a shack in an informal settlement, but it was later decided that using such a dwelling could incorrectly imply a societal misconception of HIV/Aids (i.e. that it is a poor person's disease). For this reason, we choose a typical, common council house. We conducted three field trips to Mannenberg, a suburb in the Cape Flats near Cape Town. During these visits a house was photographed from all sides to get a sense of the dimensions and general look. Photographs were also taken inside the house. These internal photographs assisted in the design of the virtual house in terms of positioning and sizes of rooms and furniture. They also provided insight into types of fittings and decoration found in a council flat home. Figure 3-8 shows the actual house that was used as a reference for the virtual house and Figure 3-9 shows the virtual house as seen in the VE.

Figure 3-8: A council house in Mannenberg, Cape Town that was used as a reference for the virtual house.

Figure 3-9: The virtual house as seen by users in the VE.

3.5 The Neighbourhood

As mentioned in Section 3.3.1, the VE was designed so that users started their experience outside the main house. This ensured that the user could decide when to begin interactions within the environment. Neighbouring houses of the original council flat were also photographed, as was the look of the neighbourhood in general. In order to create a neighbourhood feel, dummy houses were created and positioned near to the main house in which the HIV supportive information was presented. The models used for these dummy houses were 3D boxes, layered with appropriate textures. Figure 3-10 shows the neighbourhood and a neighbouring council house. Figure 3-11 shows two of the dummy houses to create the virtual neighbourhood.

Figure 3-10: The neighbourhood and the photographed council houses. Similarly structured council houses can be seen in the neighbourhood. These houses were also modelled and positioned within the VE to provide a virtual neighbourhood, and a context for the main house.

Figure 3-11: Screenshots of the outside road. This is where the user begins their VR experience.

3.5.1 The Food Items

During the storyboarding process, nine different food groups were identified. For each of these groups, the most important food items belonging to that group were identified. Between three and seven items were then chosen for inclusion in the VE. With the importance of using both locally available and affordable food items, trips to local supermarkets and fruit markets were conducted. At these shops, the cheapest brand of the food item was purchased. Between four and six photographs were taken of each of the food items, from different angles. Figure 3-12 shows a carton of maas, a cultivated milk product commonly consumed in South Africa, that was photographed from six different angles. These images were used to create a texture file that was placed onto a 3D model. The end product can be seen in Figure 3-13.

Figure 3-12: A carton of maas was photographed from 6 different angles. These images were then used as a texture for the 3D maas carton.

Figure 3-13: The 3D model of maas, as presented in the VE. The photographs shown in Figure 3-12 were used to assist with the creation of both the physical structure and texture seen here.

For items such as tin cans, it was possible to remove the labelling. This label was then scanned and touched up, using Adobe Photoshop 7. Besides providing the basis for the textures, the food photographs also assisted with the modelling of the physical structure of the items. Table 3-1 lists all the food items that were photographed and modelled.

Table 3-1: There were between three and seven different food items in each of the nine groups. Each of these items was photographed to create a 3D model with an accurate, local, familiar texture.

FOOD GROUP	FOOD ITEMS
Fats & Oils	A block of butter, bottle of plant oil and some takeaway food.
Sugars	A slab of chocolate, packet of sweets, can of coke, packet of biscuits and bag of sugar.
Herbs	Garlic, curry powder, chillies, rosemary, mixed herbs and parsley.
Milk	Maas, yoghurt, cheese and milk.
Energy	Nuts, seeds, potatoes, cereals, bread, rice and pap (maize meal).
Vitamins	Vitamins B, A, C, E, Magnesium and Selenium
Proteins	Meat, chicken, fish, eggs, beans, peas and lentils
Fruits	Oranges, apricots, mangos, guavas, paw paws and yellow peaches
Vegetables	Spinach, brussel sprouts, cauliflower, carrots, pumpkin, tomatoes and squash

3.6 The VE Soundtrack

The VE soundtrack consists of both the audio sound tracks for all the dialogues of the four agents within the VE, as well as background and ambient sounds. In this section we describe the processes used to get these different audio components.

3.6.1 Voice Recordings for Agents

Each of the drama students (see Section 3.1.3) was given a description of the character they were playing as well as the necessary scripts. The dialogues were taken from the event flow document (described in Section 3.3), and formatted into appropriate voice recording scripts (font size, line spacing). Studio time was booked at the Contemporary African Music & Arts Archive (CAMA), a small recording studio based at the University of Cape Town. Originally it was planned to record the lounge scene with all three actors together. Unfortunately, CAMA has a limited space capacity and it was not possible to accommodate a group recording session. As a result, each of the recordings was done separately. However, the three actors did rehearse the scene together beforehand in a similar setting as that found in the VE (see Figure 3-14). This assisted in the understanding of the scene as a whole and also provided insight into group dynamics. Additionally the group video footage was used extensively when creating the lounge animations (to be discussed in Section 3.7.2). The audio files that resulted from this recording were split up into manageable segments lasting a maximum of 40 seconds. These segments were converted to wav files and were related to an agent. This is important for scripting purposes since a voice clip must always be connected with a virtual character.

Since the kitchen scene did not involve a group setting, the voice recordings for that character were conducted separately.

Figure 3-14: On the left, the three actors are rehearsing their speeches in a group setting. On the right, the virtual agents are shown.

3.6.2 Background Sounds

For this environment, both ambient and sound events were sourced from the Internet. Neighbourhood sounds such as the low hum of traffic and barking dogs were downloaded from 'Partners in Rhyme' (www.partnersinrhyme.com), an online library providing free sound effect audio files. They were played during Scenes 1 and 2 when the user was outside the house. Additionally, sound clips for turning taps on and off, and running water were downloaded and used for animations occurring at the sink in the kitchen.

3.7 Creation of Agents

There are two specific tasks to complete when creating the virtual agents: Designing and developing the actual model (physical appearance, textures) and the animations of this model.

3.7.1 The Models

The creation process started with a general description of each agent required. There were three agents meeting in the virtual support group, and one agent presenting the nutritional information in the kitchen. We set out to find four individuals who would act as models for these four virtual characters. This became a difficult task due to the high level of stigma around HIV/Aids in South Africa. We could not find people who were comfortable being photographed, and thus being represented as an HIV+ person. Because of this, we decided to use a fictional character for reference purposes, and a graphic designer created character sketches from three different angles. These can be seen here in Figure 3-15.

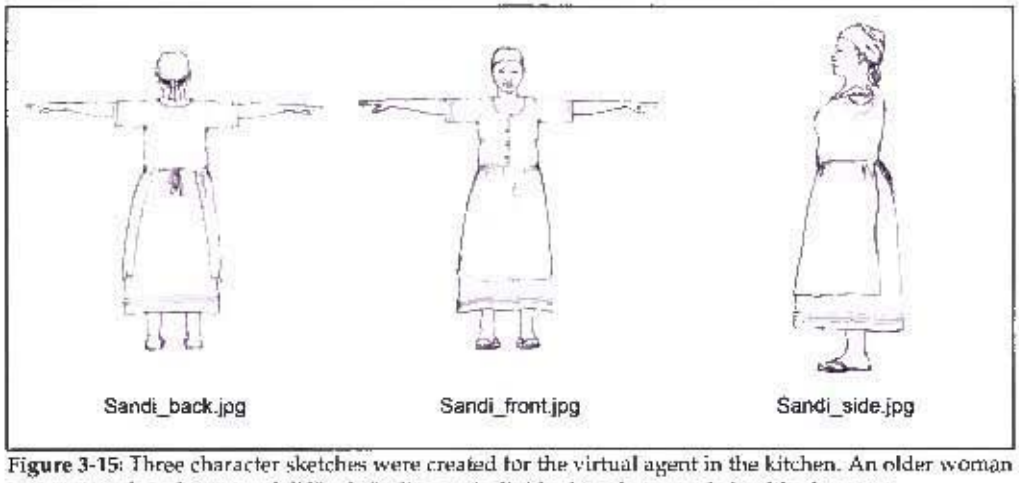


Figure 3-15: Three character sketches were created for the virtual agent in the kitchen. An older woman was required, and it proved difficult finding an individual to photograph for this character.

The original plan was to create more character sketches for the remaining three agents in the lounge. At this point in time, the voice recordings (discussed in Section 3.6.1) were taking place. The three drama students that provided the voices for the virtual agents understood that they were playing characters / roles and had no problems being photographed and represented within the environment. Using this different technique, a number of different angles were used, as can be seen in the contact sheets in Figure 3-16.

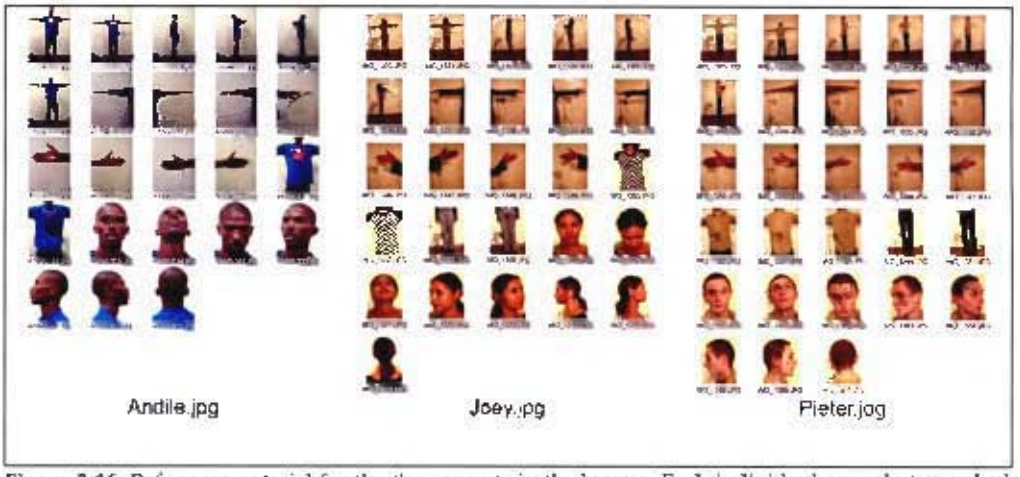


Figure 3-16: Reference material for the three agents in the lounge. Each individual was photographed from a number of different angles. These images were used as textures on the 3D models. These individuals also provided the voices for the three characters.

3.7.2 The Animations

Two different techniques were used for animations on the four characters.

One method was to create animation sequences specific to a voice recording. The maximum duration of these was 40 seconds and video footage (taken during voice recordings) was used as reference material. This animation technique was used entirely for the two characters in the lounge (*Joey* and *Pieter*). The positions for these characters do not change through-out the VE – they remain seated on the couches. The third character in the lounge (*Andile*) had similarly structured sequences for the support group scene, but due to him moving around in Scenes 1 and 2, additional separate sequences such as *walk, turn 45°, sit down* and *stand up* were required. All three lounge characters also had short animations such as *head nod, head shake* and *head tilt*. These were played randomly during other character's speeches to ensure that the characters were not completely stationary. This is a common technique to ensure that the agents do not look lifeless.

The character in the kitchen (*Sandi*) also had a number of predefined animation sequences that were used in conjunction with audio files of a maximum 50 seconds. The actress who provided the character's voice also acted out ten sequences of events, which were video recorded and provided bases for the predefined sequences.

However, the number of animations required for this character was dramatically more than the lounge agents. And there is a high expense associated with individualised animations that are only specific to one voice clip and are inherently not re-usable. Half way through the development of animations for the kitchen character, this problem was identified. A number of predefined long animation sequences had already been developed. So this animation set was then expanded upon to include a list of shorter, generic, re-usable animation sequences, lasting a maximum of three seconds. The sub-scenes for each of the nine food bowls provide a good example of where this type of animation process was useful. The animations that were created included *walk, turn 45°, pick up bowl from table, pick up bowl from shelf, take out food item, shuffle backwards with bowl in arm, shrug shoulder with bowl in arm, gesture to self with bowl in arm, gesture to table with bowl in arm, gesture to shelf with bowl in arm, put food back in bowl, shuffle forward with bowl in arm, return bowl to table, return bowl to shelf, walk backwards.*

3.8 Building the VE: Putting It All Together

This research was funded by the Collaborative African Virtual Environment System (CAVES). One of the goals for the CAVES research project was to create a VE authoring tool that could be used by non-programmers to create useful VEs for South African individuals and/or market. This authoring tool, named VRDirect, was built on top of the commercial games engine, Gamebryo. The creation of the VE discussed in this chapter was done during actual implementation and design of VRDirect. This VE (along with two others), ensured that it was possible to use VRDirect to create a comprehensive, local-centric, appropriate VE. One useful outcome of the synchronous development of the authoring tool and the actual VE was the real-time identification of software features. For example, during the scripting of this VE, it was realized that object attachment had not been considered in the planning of VRDirect. This was a very important feature for the character in the kitchen since each food item had to be taken out of a bowl. To do this, the food items needed to be attached initially to the bowl, then to the character's hand, then to the table.

VRDirect was used to put all the components discussed in this chapter, together into one single VE. The static objects and the set were imported into VRDirect as were the agents. The animations for each agent were imported with the agent and each animation could be accessed within VRDirect. Once the static scene was set up, we began the process of scripting interactions. These interactions could occur between the user of the system and other agents in the VE, or between the user and other objects in the VE. Scripting includes instructions on when to play an audio file and when to play an animation. The position of the user is usually used to trigger the sequences of events. Scripting in VRDirect is based on numerous sets of condition-action pairs [39]; if a certain group of conditions are met, a set of actions would result. Scripting was done using Python, an open source, freely available scripting language. The amount of scripting required depended on the scene complexity, and also to a larger extent, the length of the animation sequences. If the animation was long and mapped directly to a single voice recording, the process of scripting the scene was very simple. That is, if a certain event occurs, play this animation and play this sound file. However, where short, basic animations were used, the scripting process took longer, since every two to three seconds a different animation had to be played. It also had to be synchronised to the dialogue itself.

3.9 The Pilot Study

After the VE was created, it was important to carry out a pilot study to identify any major technical flaws or bugs within the system. Additionally, since we imagined that our users would have minimal, if any, prior computing experience, we wanted to test the VE with similar technically inexperienced users. Two women were recruited to test the VE stage of the experiments. These women worked fulltime at the University of Cape Town as cleaning staff and had never used a computer before.

These two users were taken through the whole VE stage of the experiment (to be described later in Section 4.8.4). Observations were made with respect to the sequence of events experienced in the VE, and their difficulties experienced in the navigational controls. After experiencing the VE, they were asked questions related to the usability of the system, and were asked to give comments. Based on this pilot study, minor alterations were made to the VE. One of these changes was that we increased the time that instructional text was visible to a user from 10 to 30 seconds.

3.10 Chapter Summary

In this chapter, we have presented the processes followed when creating a VE aimed at providing social support to HIV+ people in South Africa. The design decisions, such as the general look and feel of the characters and the virtual content itself, were particularly important for this research — we wanted the VE to be familiar to the novice user. It was also our intent to present localised content, and this is particularly challenging if one looks at the types of virtual characters available for download from the Internet. Field trips to a suburb in the Cape Town area, as well as supermarket purchases, aided with the creation of this localised environment.

It is important to consider the costs involved in building a VE, particularly in a developing country such as South Africa. Two animation techniques were used in the creation of the VE for this research: lengthy, tailored animation sequences and short, re-usable, gesture sequences. The second technique, although more time intensive during the scripting stage of the VE creation, is a much more affordable animation method.

In the next chapter, the experimental design is presented. The concepts relating to the variables in the experiments arise directly out of the five identified aspects of nutritional support. They are *Food Intake, Vitamin Intake, Water Intake, Preventative Dietary Behaviours* and *Food Safety*.

Chapter 4

Experimental Design

In order to test the effectiveness of using a VE to provide informational support to HIV+ people, a user experiment was conducted. This chapter describes the design of that experiment, and its details. All participants were HIV+ women and the justification for this is found in Section 4.7.

4.1 Research Questions

The experiment sets out to answer the following two research questions:

1. Are VEs effective in providing informational support to HIV+ people?

2. Are VEs better at providing informational support to HIV+ people, as compared to the more traditional paper medium?

The experiment was based on a pre- post-test experimental design, in which participants were seen on three separate occasions. Baseline (i.e., pre-test) data was captured at the first and second meetings. The intervention was introduced at the second encounter, and follow-up (i.e., post-test) data was recorded at the third meeting. The intervention was either the viewing of the informational VE, or the receiving of a textual description of the VE. Those participants that belonged to the control group did not experience any intervention but did attend all three scheduled meetings. The three meetings per participant provided data for both baseline and follow-up measures for a number of variables. Comparisons could then be made between the time periods. In order to quantify the effectiveness of each of the interventions (to answer the first research question) and, to compare them against each other (in answering the second), two specific areas were explored. These were HIV-related dietary quality and knowledge of food safety behaviours.

To test for changes in subjects' HIV-related dietary quality and food safety knowledge, the following variables were defined. The only independent variable was *Intervention*. The two dependent variables used for the experiment were *Dietary Quality* and *Food Safety Knowledge*. Each of the dependent variables had two sets of data associated with it, corresponding to the pre- and post-tests respectively. The variables are explained below.

4.2 Independent Variable: Intervention

The independent variable defined for this study was *Intervention*. It had three levels and was manipulated by placing a participant in one of the three experimental groups:

- *VE*: Participants in this experimental group experienced the VE during the second meeting.
- *Text*: Participants in this experimental group received a textual description of the VE content during the second meeting.
- *Ctrl*: Participants in this group acted as the control group in the experiment, and were not given any intervention at the second meeting. They did provide measurements for all variables however, and received a textual description of the VE content at the completion of the experiment.

4.3 Dependent Variable: Food Safety Knowledge

The first dependent variable defined for this experiment was *Food Safety Knowledge*. It was a measure of subjects' knowledge on a number of key issues related to the correct and safe food handling behaviours. Knowledge gains in the area of food safety were measured through the use of a modified version of the Food Safety Knowledge Questionnaire developed by Medeiros and her colleagues [80]. A discussion is presented later in Section 4.5.4 describing the modifications made to the original instrument. The questionnaire can be used to determine the effectiveness of an education-based intervention program by administering it both before and after the food safety program is introduced. The version used in this research study was a 12 item scale with each item being scored as either correct (1) or incorrect (0), resulting in a total score for *Food Safety Knowledge* between 0 and 12. Each item in the questionnaire had two variables defined in this study, corresponding to the two pre- and post-tests observations. Thus, the variables comprising the *Food Safety Knowledge* concept are *Pre FS1, Post FS1, Pre FS2, Post FS2* through to *Pre FS12* and *Post FS12*. The modified Food Safety Knowledge questionnaire is presented in Appendix B1.

4.4 Dependent Variable: Dietary Quality

The second dependent variable defined was *Dietary Quality*. This variable is a collective term for 24 dependent variables, all of which are indicators of HIV-related dietary quality. The dependent variables are discussed below and are also presented in Table 4-1.

4.4.1 Food Intake (Food Groups and Variety)

There are five food groups that were identified and measured in this research (Milk, Energy, Fruit, Vegetables and Proteins). Food intake is measured for each of the five groups, at both the pre- and post-tests, resulting in ten dependent variables for food intake in the food group category. These are *Pre Milk, Post Milk, Pre Energy, Post Energy, Pre Fruit, Post Fruit, Pre Veg, Post Veg, Pre Protein* and *Post Protein*).

Data are collected for these variables through analyses of two 3-day food diaries. The scoring technique used yields a score between 0 and 10 for each of the five food groups. A score of 10 represents a diet of a person who consumed at least the recommended minimum number of servings for that particular food group. A score of 0 reflects that no servings were

consumed from that particular food group. For consumption of servings between these two situations, the scores were calculated proportionately.

In addition to the variables for the five food groups, dietary variety was also measured. This variety variable scored between 0 and 20, and comprised of two scoring items. The first relates to variety within the protein food group (Variety Within), and the second (Variety Among) relates to overall variety among the different food groups. A diet that had variety within a food group as well as variety overall, is considered superior to a diet with a monotonous source [73]. As with the food group category, measurements were taken at both pre- and post-tests, resulting in four dependent variables for measuring variety in the participants' food intake. They are *Pre Variety (Within)*, *Post Variety (Within)*, *Pre Variety (Among)* and *Post Variety (Among)*.

Scores for *Pre Variety (Within)* and *Post Variety (Within)* range from 0 and 5 and were based on the number of different protein sources found in a participant's diary on each recorded day. If at least three different sources of protein were found, the participant scored 5 for the respective variable (*Pre Variety (Within)* and *Post Variety (Within)*). Having two different sources of proteins yielded a score of 3, while having only one source of protein resulted in a score of 1. Obviously, having no proteins in the diary for a day would result in a score of 0 for either *Pre Variety (Within)* or *Post Variety (Within)*. Scores for *Pre Variety (Among)* and *Post Variety (Among)* ranged from 0 to 15. A participant scored the maximum 15 if she consumed at least one serving from each of the five food groups under observation. For each food group that was missing (i.e. at least one serving from that group was not consumed) 3 was subtracted from the *Pre Variety (Among)* or the *Post Variety (Among)* score, depending on which meeting the measurement was observed.

4.4.2 Water Intake

Data for this variable was also taken from the self-completed food diaries. The instructions presented in the interventions regarding water intake, recommended that people living with HIV/Aids drink eight glasses of clean, safe water each day. Data collected for this variable was an average of whether the recommended amount (eight glasses) was drunk on each of the three days of the food diary. This variable was scored in the same manner as that described for Food Intake (see Section 4.4.1). A score of 10 was given if the participant drank the recommended amount of water on that particular day. If no water was drunk during that day, a score of 0 would be given. Between this, scores would be proportionately calculated. This created three scores for water from each of the diaries. The score was then aggregated to get a single score for each of the two time periods. Measured at pre- and post-tests, the respective variables were *Pre Water* and *Post Water*.

4.4.3 Vitamin Intake

Six different vitamins and minerals (Vitamins B, A, C, E, Selenium and Iron) were recommended in the interventions. We were interested in investigating whether these vitamins would be incorporated into participants' eating habits. We had originally planned to record whether each of the six vitamins showed improvements in terms of occurrence in participants' weekly intake. We did not want to ask leading questions. We thus did not specifically ask about each of the six vitamins, but rather asked participants to list all vitamins consumed in the previous week. We had originally planned to have six separate variables for analysis of these vitamins. However, after looking at all the participants' responses, it was found that all individuals that had consumed vitamin supplements had received these supplements through government clinics. This supplement supplied to clinic attendees through the Department of Health, is a multivitamin. For this reason, we decided to use a single variable which would be dichotomous. Corresponding to the pre- and post-

test observations, the two variables were *Pre Vitamin* and *Post Vitamin* respectively. These two variables were scored as 1 if participants had consumed any additional vitamins during the previous week, and 0 otherwise.

4.4.4 Preventative Dietary Behaviours

Most literature in the area of nutritional support for people living with HIV/Aids includes practical advice to maximize food intake during, and after, common HIV/Aids-related infections [9, 58, 60]. They often include dietary approaches and more traditional, local methods for dealing with common HIV-related infections. One particular problematic area experienced by HIV+ individuals is stomach infections. We were interested in whether participants would incorporate such recommendations that assist with appropriate food intake into their lifestyles. Three specific dietary behaviours were recommended in the interventions that aide with the prevention of stomach infections. These recommendations were the consumption of specific amounts of three food items: carrots, pumpkin seeds and garlic. For each of the three items under investigation, a maximum score of 10 was given if the participant consumed the minimum required servings in the previous week. A score of 0 was given if the participant consumed none of the specific item in the same time frame. Situations between these two extremes were calculated proportionately. The variables used for the three preventative dietary behaviours, as measured at the pre- and post-tests were *Pre Carrots, Pre Pumpkin, Pre Garlic* and *Post CS Carrots, Post Pumpkin, Post Garlic* respectively.

To summarize, Table 4-1 presents a summary of the variables under investigation. The possible scores for each of these variables are also given.

Table 4-1: The dependent variables are categorized into the two concepts of Food Safety and Dietary Quality. Each variable has a minimum and maximum value that a participant can score.

Variable	*Min*	*Max*
Food Safety:		
• Knowledge Score	0	12
Dietary Quality:		
• Food Intake – Servings Score (x5 food groups)		
Pre Milk and *Post Milk*	0	10
Pre Energy and *Post Energy*	0	10
Pre Fruit and *Post Fruit*	0	10
Pre Veg and *Post Veg*	0	10
Pre Protein and *Post Protein*	0	10
• Food Intake – Variety Within Diet		
Pre Variety (Within) and *Post Variety (Within)*	0	5
• Food Intake – Variety Among Diet		
Pre Variety (Among) and *Post Variety (Among)*	0	15
• Water Intake		
Pre Water and *Post Water*	0	10
• Vitamin Intake		
Pre Vitamin and *Post Vitamin*	N	Y
• Preventative Dietary Behaviours (x3 behaviours)		
Pre Carrots and *Post Carrots*	0	10
Pre Pumpkin and *Post Pumpkin*	0	10
Pre Garlic and *Post Garlic*	0	10

4.5 Measurement Instruments and Questionnaires

A number of instruments and questionnaires were used to measure changes in the dependent variables. And, semi-structured interviews were conducted with the *VE* participants. Details of these instruments are presented below.

4.5.1 Food Diaries

To investigate our experimental subjects' dietary quality before and after the intervention program, each participant completed two food diaries. Previous research in the area of food diaries have found that consecutive days are not independent of each other, and that participant motivation tends to decline over consecutive days [89]. We thus ensured that each food diary consisted of 3 non-consecutive days (2 weekdays and 1 weekend day) [89]. For accurate recording of dietary intake, it is recommended that participants keep the diary on them during the days of data capture. For this reason and due to the stigma surrounding HIV infection in South Africa, the food diary did not contain any mention of the words "HIV" or "Aids".

Drawing from the experiences of Robson and her colleagues, the following recommendations were followed [65] :

- The food diaries were small in size to increase their portability, and encourage our participants to carry them around with them when they were away from home. They were A5 in size, and could easily be folded into A6.
- The diaries were visually appealing: Pictures of different food items were included on all pages of the food diary. A clear font (Verdana, size 12) was used.
- The instructions for completing the food diary were detailed: A hypothetical, typical meal and a list of hints and tips were provided at the beginning of the food diary for later reference.

The Food Diary template that was designed for this research is presented in Appendix B2.

Some researchers who make use of Food Diaries provide their participants with measuring scales [65]. Since carrying around a measuring scale would attract attention to our HIV+ subjects, this was not possible. Instead, our participants were asked to estimate consumption amounts based on common household measures (such as cups and teaspoons), natural units (e.g. slices of bread) or fractions of packaged foods (e.g. ½ can of baked beans). Data for determining whether participants had drunk the recommended amount of water per day was also captured through these two food diaries.

All food items noted in the food diaries were categorized into the different "good" food groups presented within the VE. They were *Milk, Energy, Fruits, Vegetables* and *Proteins.* Water consumption was treated in the same manner as these five mentioned food groups. The recommendations for the five food groups under investigation were for individuals to consume at least the specified minimum amounts per day. The only food groups that were included in the VE, but excluded from measurement were *Fats & Oils* and *Sugars.* These two groups contain food items that nutritionists recommend people with HIV avoid and thus require a different analysis to the other food groups. Nutritionists and dieticians are able to calculate the amounts of different types of fats present in their diet (e.g. saturated, unsaturated, cholesterol, etc.). The authors however, felt that this level of detail was not required for this research.

Participants were asked to document the amount consumed of each captured food item. This amount was then converted into a portion size. Some items were easy to convert, since unit

amounts were used as a classification for a serving. For example, in the *Fruit* food group, one medium sized apple is one fruit portion. However, there were numerous items that were more problematic to categorize. For example, participants recorded that one chicken breast was consumed. It was thus necessary to convert each type of chicken piece, to ensure that an accurate portion size calculation could be made. In a similar manner, the use of household measures (such as 2 tablespoons) was problematic during the serving size calculations, since literature recommended different measuring tools (such as cups).

Due to these concerns, the authors contacted the Sports Science Institute of South Africa [90] in Newlands, Cape Town to provide assistance with the problematic food items. Madelaine Carstens, a dietician and research assistant working at the Institute was regularly consulted for clarity on food diaries and categorization. Additionally, a Food Photo Manual [91], created by the Medical Research Council [92] of South Africa, was provided to the authors for the duration of data analysis. This colour-paged file contained actual measurements of commonly used items for a large number of food items. Also, it included locally available food items whose measurements were difficult to find elsewhere. The provided measurements included teaspoons, tablespoons, serving spoons and cups. For items not covered in the Food Photo manual, items from supermarkets were sourced for actual measurements (e.g. "one packet of macaroni").

The food diaries were categorized into the number of portions consumed of each of the five food groups. This portion number was then converted into a percentage of the number of portions recommended for a particular food group. And, this percentage was then converted into a score out of 10. To measure dietary variety, the scoring technique adopted was a hybrid of the Healthy Eating Index (HEI) [72, 93] and the Dietary Quality Index-International (DQI-I) [73]. Details of these can be found in Section 2.7.1.

4.5.2 The Specific Food Consumption Questionnaire

Since the recommendations for the preventative dietary behaviours and vitamins were specifically for a one week period, the three day food diaries were not suitable for measuring these items. For example, participants were encouraged to consume a specific amount of carrots in a week. Therefore, using a 3-day food diary would be problematic if the carrots were consumed on a day in the previous week that the participant was not recording food intake.

The Specific Food Consumption Questionnaire was thus designed specifically for this research and is presented in Appendix B3. It contains four items. The first three are related to the three preventative dietary behaviours (*Pre Carrots / Post Carrots, Pre Pumpkin / Post Pumpkin* and *Pre Garlic / Post Garlic*) and the final item provides data for the *Pre Vitamin* and *Post Vitamin* variables. For each question, participants were asked if they had consumed any amount of the specified food item in the previous week. If participants answered affirmatively, quantities were recorded.

4.5.3 Food Diary Experience Questionnaire

The Food Diary Experience Questionnaire was designed specifically for this research and consisted of six items. The reason for its inclusion was to understand subjects' experience of completing a food diary. It was used to document the difficulties, challenges and benefits facing our particular sample of HIV+ women living in South Africa in using a food diary for recording of dietary intake. If a fundamental flaw existed in the use of such instruments, it would become apparent in the questionnaire.

The majority of participants' home language was isiXhosa and since the questionnaire was only available in English, it was decided to administer it verbally. This also gave the experimenter an opportunity to probe for further explanations and gain the broadest understanding of participants' experiences in completing a food diary. This questionnaire is presented in Appendix B4.

4.5.4 Food Safety Knowledge Questionnaire

In order to measure the Food Safety Knowledge dependent variable, a questionnaire was used. This questionnaire was based on a knowledge and attitude scale designed by Medeiro and her colleagues in Ohio, United States of America. In designing the original knowledge questionnaire, 43 knowledge questions were identified by a panel of experts [80]. This question set was then pilot-tested with three groups of participants. The first were attendees of a low-income nutrition education program in Ohio and the second were university students in their first nutrition course at the Ohio State University. The third population sample consisted of graduate students in nutrition, dietetics, or hospitality management.

Item analysis, validity and reliability testing on these 43 items produced a final knowledge questionnaire containing 18 items. The 18-item instrument showed internal reliability (Cronbach's $\alpha > 0.75$) and produced similar results in test-restest for a control sample (i.e. did not receive educational intervention). The 18 item knowledge questionnaire also had instructional sensitivity (mean score increase of more than three points after instruction). To determine the construct validity of the original questionnaire, comparisons were made for each questionnaire item between the mean pre- and post-test scores. Eleven of the 18 items showed significant differences [80]. Face validity and content validity were addressed through the use of focus groups and identification of correct practises by expert panels respectively.

Medeiros and her colleagues state that the knowledge questionnaire can be modified by excluding some of the original 18 items. This is particularly applicable if some of the items are not covered in the intervention being examined.

When investigating this instrument as a tool to measure improvements in knowledge of food safety behaviours, it was noted that six of the questionnaire items were inappropriate since they were not included in the VE content. These original items are shown below in Table 4-2. The third item listed in the table below (original questionnaire item 5) consists of adequate cooking temperatures and this topic was not presented in the nutritional support in the VE. Participants could therefore not be questioned on the subject.

The remaining twelve items were then examined to ensure that they were locally relevant and did not contain references to food items or behaviours that would be unfamiliar to the South African target group. Only one item was changed. In the original questionnaire, item number 7, the item referred to the shaping of ground beef patties. In South Africa, the term 'patties' was not completely familiar, and so this was changed to 'ground beef burgers'.

Table 4-2: Six questionnaire items from the original questionnaire [80] that were omitted for the current research. They were excluded since the intervention did not cover information relating to the questions

Original Item No	Question
2	If you have diarrhoea, it's okay to prepare food for others in the family if you wash your hands first. a) Agree b) Disagree c) Not sure
3	When you can't see any pink color inside a cooked hamburger patty you know all of the harmful germs have been killed and the hamburger is safe to eat. a) Agree b) Disagree c) Not sure
5	Hamburger patties should be cooked until the temperature in the middle is: a) 130 degrees F b) 140 degrees F c) 150 degrees F c) 160 degrees F c) Not sure
9	Pasteurization of milk and fruit juice helps prevent foodborne illness. a) Agree b) Disagree c) Not sure
15	Soft cheeses such as Mexican-style soft cheese (queso fresco) or Brie a) Avoid b) Okay to eat c) Not sure
18	Cold deli salads a) Avoid b) Okay to eat c) Not sure

4.5.5 Technology Familiarity Questionnaire

The Technology Familiarity Questionnaire was also designed specifically for this research study. We assumed that participants chosen for this experiment would have minimal prior computing experience and thus included this questionnaire to test these assumptions. The three item questionnaire included questions relating to prior computer use, knowledge of the Internet and the types of technologies participants had access to in their homes. The Technology Familiarity Questionnaire is presented in Appendix B5.

4.5.6 Interview Questions

Roughly one third of the participants explored the VE. After this VR experience, semi-structured interviews were conducted. These questions covered specific areas of interest and here, we give motivation for including them.

The first four questions were used to gain an understanding of the participants' subjective experiences of the VE, as well as their previous computing experiences. With the next two questions, we asked the participants to identify the VE features they enjoyed the most, and the least. This gave us an opportunity to understand some of the pitfalls and advantages of

such a system. Kalichman and Sikkema identify the need to introduce supportive interventions to people living with HIV/Aids, especially near to the time that they test HIV-seropositive [7]. We were interested in finding a good time frame relative to a diagnosis in which to introduce the VE to people living with HIV/Aids. Also, we were concerned that the amount of information presented in the VE might result in information overload due to the sheer amount of it. A question relating to how participants responded to this large amount of information was thus included.

Although a lot of HIV-related information is available on the Internet, we assumed that such information may not be as readily available for our participants and thus included a question to probe this. It is our opinion that the VR system designed for this study could be placed at a general government clinic or day-hospital. If this were to happen, we were interested in whether participants who had already seen the VE would return for subsequent VE exploration session. Participants were asked to comment on this. A feature of VEs that has not been addressed in this research is the use of collaborative environments in which users could interact with other HIV+ users who are residing at geographically different locations. We were interested in whether such a feature would be of benefit to our participants. Finally, we were interested in our participants' idea of appropriateness of using a VR application, as compared to a TV program or a video recording. The questions used during the interview are presented in Appendix B6.

4.6 Materials

Besides the measurement instruments and questionnaires discussed above in Section 1, other materials were used during the experiments. Discussions of the venues, computer equipment, ethical approval and considerations, and the experiment schedule are now presented.

4.6.1 Venues

Due to the stigma associated with HIV infection in South Africa, it was imperative that the experiments were conducted at a site where participants would feel comfortable, safe and be in an environment where they could be open and honest. We therefore chose to use a government clinic for the experiment venue. We started the experiments at a Midwife Obstetric Unit (MOU) at a government hospital in Green Point, Cape Town. Initially the experimenters were informed that all participants could be sourced from this venue. However, three weeks into the experimental schedule, it was realized that another venue would be required since subject drop-out rates were relatively high. The head counsellor at the MOU also worked part-time at another government clinic and assisted with the new venue organization. The second clinic was situated in Brooklyn, Cape Town.

At both venues, a dedicated room was made available to the experimenter. At the MOU, participants met weekly in a support group for HIV+ mothers and HIV+ pregnant women. The experimenter met with participants directly after the weekly support group. Most of the interviews and questionnaire administrations were done in the room where the support group met. For six weeks, a computer was brought to the MOU on the day the support group met. It was placed in the experiment room which was usually used for one-on-one counseling sessions. The door to the room was closed during the VR experience. This provided some privacy, and also ensured that the users were not distracted by external physical factors. While care was taken to ensure this, it was physically impossible since the walls did not extend completely to the ceiling.

At the second venue in Brooklyn, HIV+ mothers visited the government clinic twice a month to receive formula food for their newborn babies. They met in a dedicated room and all questionnaires were administered in this room. No computer was used at the second venue. Note that the first and third meetings coincided with participants' scheduled visits for formula food, but the second meeting did not. Participants came to the venue specifically for the experiment.

4.6.2 Computer

The desktop PC that was used to display the virtual environment had the following hardware specifications:

- Processor: Pentium 4 CPU 2.80 GHz
- Graphics Card: NVIDEA GeForce FX 5700. The frame rates varied with scene complexity, ranging from 12 to 40 frames per second.
- Memory: 512 MB of RAM
- Sound Card: SoundMAX Integrated Digital Audio
- Hard Drive: 120Gb IDE
- Monitor: 17"

The PC was stand-alone, in that it was not connected to any network. Input to the VR system (i.e. navigation and object selection) was through a keyboard and mouse. Participants wore standard stereo headphones for the VE soundtrack.

4.6.3 Ethical Approval and Considerations

Approval was gained from the hospital (first venue) through meetings with the head matron in charge as well as the head dietician of the hospital. At the second venue, permission was granted from the head sister in charge of the facility. The University of Cape Town requires that any studies involving human subjects needs ethical approval from a designated committee [94]. This was obtained from the Science Ethics Board with the following considerations.

Participants' confidentiality must be enforced during the experiments and after their completion:

During the experiments, subjects were informed at the start that they would be given a number and that all other correspondence with them would use that number. Participants received an Information Sheet (see Appendix B9, B10 and B11 for the Information Sheets for the Text, VE and Control participants respectively). Each subject signed an informed consent form (see Appendix B7) that included their right to anonymity and their right to discontinue involvement in the experiment at any time. These rights were also specifically discussed in both English and isiXhosa with all participants.

To address confidentiality concerns post experiments, the original consent forms (only documents giving participant names) are housed at the offices of Prof E.H. Blake (supervisor of this research) at the Computer Science Department, University of Cape Town. Additionally, the audio files that contained the interview transcripts were destroyed after they were transcribed.

Another consideration raised by the Science Faculty Ethical Board, was that additional social support should be made available to participants to ensure that participants are not only informed of dietary aspects but are also advised on the full suite of issues related to their HIV+ status. There were two HIV counsellors available to the subjects and all participants

were informed of the counselling service. The two HIV counselors were supervised by Ms Mignon Coetzee, a clinical psychologist and HIV counsellor involved in designing the VE narratives (see Section 3.1.5).

There was concern over language barriers between the experimenters and participants. Because of this, the two HIV counsellors also acted as translators for the duration of the project and provided assistance when required. These translators already worked at the venues and the translations were between the English and isiXhosa languages. Participants were familiar with these two individuals, and were able to ask open questions in their home language. These questions were immediately translated into English and conveyed to the main experimenter. The experimenter gave timely responses which were in turn, translated into isiXhosa.

It was decided to conduct the experiments at public health care facilities. Many research studies at universities use student volunteers and often, the experiment venues are located on university campuses. The negative stigma surrounding HIV infection in South Africa is high, and it is important that HIV+ subjects do not feel further stigmatised by forcing attendance at an unfamiliar venue. Participants may feel isolated or singled-out if they are asked to attend a venue (such as a computer laboratory on university campus). Participants may feel that other people at the venue know of their HIV status, and by putting additional unnecessary strain on the individuals, can distract from the VR experience.

4.6.4 Experimental Schedule

Each participant was seen three times over a five week period. These meetings were scheduled differently for each participant depending on starting dates, but consisted of:

- An initial meeting where recruitment into the study was made and some preliminary baseline data was collected.
- The second meeting where additional baseline data was collected and the intervention was introduced.
- The third meeting where the follow-up data was collected.

The second meeting took place one week after the first meeting, and the final meeting four weeks after the second meeting. From meeting the first participants, to the final meeting of the last participant, the experiments took eight weeks to complete. Table 4-3 shows the numbers of participants that attended each of these meetings.

Table 4-3: The number of participants attending each of the experiment meetings, showing the return rates observed. The venue from which the participant was recruited is also shown.

Venue	Exp Group	Meeting 1	Meeting 2	Meeting 3
Clinic 1 (Green Point)	*VE*	11	9	8
	Text	7	3	2
	Ctrl	5	3	3
Clinic 2 (Brooklyn)	*VE*	0	0	0
	Text	8	4	3
	Ctrl	8	7	6
All Participants	***VE***	**11**	**9**	**8**
	Text	**15**	**7**	**5**
	Ctrl	**13**	**10**	**9**
GRAND TOTAL		**39**	**26**	**22**

4.7 Participants

As can be seen in Table 4-3, 39 participants were seen overall for the initial meeting. From this sample, 26 returned for the second meeting. And of these 26, 22 participants attended their third and final meeting, resulting in 22 complete data sets. Although care was taken to ensure that there was an equal amount of participants placed in each of the experimental groups, this was not possible due to the high rate of subject drop-outs. For example, the return rate for the *Text* group was considerably lower than the other two groups. This was realized early on in the experimental period, and we therefore decided to recruit more participants for this group. We were able to dynamically change the number of participants in each group since most participants had different starting dates.

It should be noted here, that many participants were new mothers, pregnant and some even gave birth during the five week experiment. Many also received their HIV+ diagnosis as a result of these pregnancies. The return rates observed here although low, are impressive considering the life circumstances of the participants.

All participants were HIV+ women. There are a number of reasons for this. Firstly, statistics for HIV infection are normally taken from pregnant women. Although it is currently not compulsory for pregnant women attending government clinics in South Africa to know their HIV status, it is a highly recommended medical test done by clinicians at such establishments. In fact, young pregnant women are highly over-represented in HIV+ populations. According to a survey conducted in 2003, about 30% of all pregnant women in South Africa are infected with HIV [8]. Secondly, we wanted our participants to return at each of the scheduled meetings, and using samples of people who already met regularly (for their support group or formula food collection) provided an accessible population.

Experimental subjects were given financial compensation for each meeting that they attended. Originally it was decided to pay even amounts for each of the meetings. However, as the drop-out rates increased, it was decided to compensate participants with R20 for each of the first two meetings. At the final meeting, participants were given R260. If a participant arrived at the last meeting, they received R300 in total for their time spent in the study. If a participant dropped out of the research study after the first two meetings, they received less financial compensation.

4.8 Experimental Procedure

This section describes the experimental procedure that was followed. During all stages of the experiment, two individuals were available to the participants. These were an HIV/Aids counsellor (see Section 4.6.3) and an experimenter. This individual administered the questionnaires, conducted the interviews and set up the computer and other technical requirements needed for this study. Instructions were communicated in both English and isiXhosa.

4.8.1 Meeting One

For most participants, this first meeting was held in a group setting due to space limitations at the venues and time constraints. Depending on the venue, this was either directly after their support group or directly after the participant received their bimonthly infant formula food. The experimenter was introduced to the participants by the head counselor or the head nurse. The experimenter then explained the format of the entire experiment and gave each participant an information sheet. The information sheet explained the format of the

experiment and gave a description of each of the three meetings. The information sheet is attached in Appendix B9, B10 and B11 for *Text*, *VE* and *Ctrl* groups respectively. The information sheet also determined the experimental group in which the participant would be placed. Participants were encouraged to ask questions at any time during the experiment. After reading the information sheet, each participant signed an informed consent form (Appendix B7). Participants then completed the socio-demographical questionnaire (Appendix B8), followed immediately by the Food Safety Knowledge Questionnaire (Appendix B1). This provided the baseline data for the food safety knowledge scores.

Upon completion of these two questionnaires, the experimenter explained the concept of food diaries. The experimenter gave each participant an empty 3-day food diary (Appendix B2). Detailed verbal instructions were then given on how to use a food diary to track dietary intake. The experimenter described a hypothetical meal and demonstrated filling these food items into the diary. This example meal is presented at the beginning of the food diary. Since food measurement can be problematic when using food diaries for data capturing, specific emphasis was made on estimation of portion sizes (using commonly available items such as a match box and a slice of bread). The last two pages of the food diary were allocated for questions arising during the data capturing process. Participants were encouraged to write down any questions they had for the experimenter. Three non-consecutive random dates in the following week were written on the front cover of the food diary. These were the days for data capture. A return date and time (for Meeting Two) were also written on the front cover of the food diary. Participants were given a pen to assist with the recording of dietary intake.

Subjects were then thanked for their time, and compensated financially (see Section 4.7).

4.8.2 Meeting Two

The second meeting was held one week after the initial appointment and involved one-on-one interaction between the experimenter and the participant. This meeting comprised of two different stages: The first was questionnaire completion, and the second stage depended on the experimental group in which the participant had been placed in Meeting One.

The meeting began with the collection of a completed food diary. The experimenter went through each captured food item and verified unclear entries. This process of verification is required when using food diaries [65]. These queries ranged from portion size clarifications (e.g. number of bread slices, size estimates using a matchbox as a reference) to explanations of specific foods that the experimenter did not recognize (e.g. Ulusu, Afal). If a participant had noted questions in the section at the end of the diary, these were addressed at this time. After this clarification process, the experimenter verbally administered the Food Diary Experience Questionnaire to each participant. Following this, participants responded to the Specific Food Consumption Questionnaire, a scale focusing on their intake of vitamins and the three preventative dietary behaviours. Lastly, participants responded to the Technology Familiarity Questionnaire.

The second stage of this meeting involved the introduction of the therapeutic intervention. For participants placed in the *Text* experimental group, the experimenter described the text pamphlet and its basic content. The pamphlet (included in Appendix C) was a text walk-through of the VE and included all the characters and areas in the house. Participants who were placed in the *VE* group went through the VE stage of the experiments (described later in Section 4.8.4). There was no second stage of meeting 2, for participants placed in the *Ctrl* group.

All participants left Meeting Two with a second food diary (with dates for data capture and a return date) and another pen. Participants in both the *VE* and *Text* groups were also given

a colour printout of the text pamphlet. Finally, all subjects received financial compensation for their time.

4.8.3 Meeting Three

The final meeting was held one month after a participant was seen at their second meeting. At this time, an experimenter collected the second food diary and once again, went through the entries to ensure clarity of the data captured. The following questionnaires were then administered to provide post-test data for the variables under investigation:

- Food Safety Knowledge Questionnaire
- Specific Food Consumption Questionnaire

Participants were thanked for their dedication to the project as a whole and any questions were answered regarding the experiment. After completing the questionnaires, participants were given the answers to all of the knowledge questionnaires. If requested, the experimenter explained the 12 points addressed in the questionnaire.

Participants that had been in the *Ctrl* group were then given a colour printout of the text pamphlet. Interestingly, one participant did not want a copy of the pamphlet. She stated that because it was written in English (not her first language), she would need help with translations. Acquiring this help at home would naturally imply disclosure of her HIV status which she had not yet done. Fortunately, in the months prior to conducting these experiments, time had been spent translating the entire VE into two other local languages of South Africa (that is, isiXhosa and Afrikaans). This was for possible expansion and improvements of the VE for a follow-up study. Following this particular subject's dilemma, a Xhosa version of the VE content was printed out and delivered to the participant four days after her third meeting.

4.8.4 VE Stage

This section below describes the process that was followed for all of the *VE* participants at their second meeting.

- **Basic Introduction**

The VE stage began with an introduction to the basic peripherals of a computer. The terminology used was "keyboard", "mouse", "box" and "screen". After this, the experimenter explained the functioning of the mouse and highlighted the effect movement of the mouse had, with respect to cursor positioning on the screen. In our previous research with participants with low computer literacy levels, we found the mouse to be a difficult concept to understand [57]. Hence, the time dedicated specifically to this peripheral.

- **The Training VE**

Upon completion of the basic hardware descriptions, a training VE was introduced. The environment that was used here contained the same basic house model used in the main VE. This served to familiarize the users with the environment as a whole, and also ensured that time wasn't wasted in creating an entirely new environment. None of the characters however, were included in the training VE. Instructions within the training environment were by means of text displayed in the top left hand corner of the screen. There were three skills that needed to be acquired during the training session, namely movement with the mouse, walking and object selection. By familiarising participants with the required controls, we ensured that difficulties with using the technology did not become an extraneous variable in the final experiment. The VE that was used for training prior to experiencing the main VE is shown here, in Figure 4-1. The textual descriptions displayed to the participant throughout the training VE are presented in Table 4-4.

Figure 4-1: Two screenshots from the Training VE: Textual instructions are displayed in the top left corner of the screen. The user is taught how to move a central crosshair over an object in the VE (e.g. the radio in above screenshot) and to select it by clicking on it.

Table 4-4: In the Training VE, textual instructions were visible in the top right hand corner of the screen and guided the step-by-step training session. Here, the instruction and the duration of its visibility are given.

Instructions to User (visible top right corner of screen)	***Duration of visibility***
The user starts the Training VE in the road. After 5 seconds, the following message shows:	
Welcome to the Training Environment: First, use the MOUSE to look around.	*Show for 30 seconds*
To move forwards, hold down the W KEY on the keyboard	*Show for 30 seconds*
Let us go into the house now and learn how to CHOOSE different things	*Show until user enters house*
When you need to choose something you will see a CROSS in the middle of the screen - like this	*Show for 30 seconds*
You must move so that the CROSS is on top of the thing you want to choose. Then, press the left button on the mouse with your 2nd finger. Try it now: Choose the radio!	*Show for 30 seconds*
The user is shown a crosshair in the middle of the screen. The above message is shown until the user moves the mouse so that the crosshair is centered on the radio object in the lounge, and presses the left mouse button.	
Well done! The first thing is in the bathroom - so walk into that room now	*Show until user enters bathroom*
You need to select the BLUE TOWEL	*Show until user selects towel object*
Well done! You have selected the towel. Now you need to find the TV in the bedroom	*Show until user enters bedroom and selects the TV object*
Well done! You have selected the TV. Now you need to find the PAN on the stove in the kitchen	*Show until user enters kitchen and selects the pan object*
Well done! You have selected the pan. The last thing you need to find is the POT PLANT in the lounge	*Show until user enters the lounge and selects the plant object*
Well done! You have selected the last object. This marks the end of your training session. Thank you for your time!	*Stays on screen*

In the Training VE, the participant began her experience in the middle of a virtual road outside the main house model. The subject started her training with navigation (using the 'W' key to walk forward) followed by orientation (mouse movement). When comfortable, the participant was asked to walk into the house. Upon entering the house, the experimental subject was systematically given five tasks of finding five different objects. These objects were placed in different rooms which forced the subject to navigate around the house and select the specified items (using the mouse click). This allowed the participant to use the skills they had acquired, and demonstrated to the experimenter whether the user was familiar enough with the navigation controls.

When participants were finished training, they were asked whether they felt comfortable with the controls and were ready to experience the main VE. One participant chose to re-explore the training environment while all other subjects were comfortable enough to move onto the main VE. The training VE took five minutes on average. An experimenter sat near to the subject throughout this training stage, and gave assistance if, and when, it was required.

- **The HIV Nutritional Information VE**

After completing the Training VE, the participants moved into the main VE designed for this research. Users were told that in the event that they couldn't see where they were within the VE (e.g. moved too close to a wall) they should move the mouse around to assist with gaining their bearings. The *VE* participants were then told that to start the main VE, they needed to walk towards the main character standing at the front door of the virtual house.

The same experimenter from the Training VE sat at the back of the room, out of sight from the user. The experimenter's duty for the duration of the main VE, was to provide assistance if it was required. However, the participants were given free range of the VE, and were able to explore the environment at their own pace using the skills they had acquired during the Training VE. The mean time spent in the main VE was 28 minutes. All participants viewed all of the available information in the VE. Following the main VR experience, semi-structured interviews were conducted. They were electronically recorded and later transcribed.

4.9 Chapter Summary

In this chapter we have described the experimental procedure that was followed to test the hypotheses for this research. We first identified the different variables under investigation. The independent variable was *Intervention* and related to the experimental group in which the participant was placed. The dependent variables were measured at two time intervals, thereby giving pre- and post-test data. The dependent variables were *Dietary Quality* (consisting of *Food Intake, Water Intake, Vitamin Intake* and *Preventative Dietary Behaviours*) and *Food Safety Knowledge.* Following this, we discussed the materials used for the entire experiment, from the venues and computer equipment, to the experimental schedule. The details of our experimental participants were then given. We then presented the experimental procedure in which we discuss the three meetings that each participant attended, and the questionnaires and other measurement instruments used at each of these meetings. The experimental results obtained from these experiments will now be presented.

Chapter 5

Results

In order to answer the two research questions underlying this study (presented in Section 1.3), statistical analyses were conducted on the data obtained from the three meetings attended by the participants. We start this chapter by describing the categorisation of participants into the three experiment groups, and follow this with demographic data. This also includes information related to the subjects' previous exposure to, and familiarity with specific technologies. This is particularly relevant since we correctly assumed that computer literacy levels among the participants would be low. We proceed with an overview of the statistical tests used to conduct this research, followed by descriptive statistics. To answer the first research question relating to changes in participants' dietary quality, the results obtained from analyses on all dependent variables are presented. These include food, water and vitamin intake, as well as the three preventative dietary behaviours. The second research question of this study investigates changes in participants' knowledge of food safety practices. Results supporting this question are then presented. Finally, the qualitative data derived from interviews with participants who viewed the VE, is presented.

5.1 Background Statistics

Before more detailed statistical analyses, some basic background information is presented. This includes the assignment of participants into conditions, demographic data, an overview of the statistical tests conducted, and descriptive statistics of all dependent variables.

5.1.1 Assignment of Participants into Conditions

Participants were randomly assigned to one of three experimental groups at the initial meeting (*VE*, *Text* and *Ctrl*). However, when assigning participants to the *VE* group, subjects were first asked if they were comfortable in the fact that at their subsequent meeting, they would be required to use a computer. They were also assured that prior usage of a computer was not necessary. The participants had recently been diagnosed with HIV, and bearing this major stressor in mind, the experimenters did not want to force people to use a computer if they were highly reluctant to do so. Two older participants expressed some unwillingness to use a computer, and were thus randomly assigned to either the *Text* or *Ctrl* groups. The remaining participants were randomly assigned to these two other groups. The breakdown of these assignments is presented below, in Table 5-1.

Table 5-1: Participants are categorized into one of three experimental groups. These were *VE* (participants experienced a virtual environment), *Text* (participants were given a textual pamphlet of nutritional information) and *Ctrl* (control group).

	Valid N	Percent
VE	8	36 %
Text	5	23 %
Ctrl	9	41 %
Total	**22**	**100 %**

5.1.2 Demographic Data

A selection of socio, economic and demographic data is presented below in Table 5-2 to Table 5-6. As can be seen in Table 5-2, roughly 70% of participants fell into the 20 to 30 age group. The majority of the participants (64%) in this study had completed up to Grades 11 and 12 of South African schooling (these are the last two years of public schooling). Only three participants had undergone tertiary studies after leaving school (see Table 5-3). Roughly a third of participants were in full-time employment at the time of the study. Another third were employed part-time and the remaining third were unemployed (see Table 5-4). The home language of most participants (bar two) was isiXhosa, one of South Africa's eleven official languages (see Table 5-5), and a principal language in the Western Cape province.

With the employment figures observed in Table 5-4, it is expected that monthly incomes would be low. The majority of participants' households (64%) relied on less than R1000 ($139 [92]) per month (see Table 5-6). The Gini coefficient is a measure that describes the level of equality within a distribution. When applied to countries and incomes, the Gini coefficient can be used to measure wealth inequality [93]. South Africa has the highest Gini coefficients in the world [94], and it is thus not appropriate to compare the monthly income observed in this sample group to a national average.

Table 5-2: Frequency table of age groups of participants.

Age Groups	Frequency	Percentage of Sample
20-30	15	68 %
31-40	7	32 %
TOTAL	**22**	**100 %**

Table 5-3: Frequency table of participants' highest educational standards obtained.

Highest Educational Standard Obtained	Frequency	Percentage of Sample
Less than Grade 7	2	8 %
Grade 8-10	3	14 %
Grade 11-12	14	64 %
Post Matric (tertiary education)	3	14 %
TOTAL	**22**	**100 %**

Table 5-4: Frequency table of participants' current employment status.

Current Employment Status	Frequency	Percentage of Sample
Unemployed	8	36 %
Part-time employed	7	32 %
Full-time employed	7	32 %
TOTAL	**22**	**100 %**

Table 5-5: Frequency table of participants' home language spoken.

Home Language	Frequency	Percentage of Sample
isiXhosa	20	90 %
Afrikaans	1	5 %
English	1	5 %
TOTAL	**22**	**100 %**

Table 5-6: Frequency table of monthly income of participants' households.

Monthly Income (of household)	Frequency	Percentage of Sample
Less than R1000 ($139) [95]	14	64 %
R1001 - R2000 ($140 - $279) [95]	5	23 %
R2001 - R3000 ($279 - $418) [95]	3	13 %
TOTAL	**22**	**100 %**

The secondary aim of this research is to investigate the use of VE as a communication medium for people who have minimal (if any) prior computing experience. Since South Africa is a developing country, computer literacy is relatively low. In Table 5-7, data relating to participants' familiarity with technology is presented. Although 8 (of 22) participants had used a computer before the time of the experiment, three of these described their computer experience as participation in six week secretarial training courses conducted prior to this experiment. Of the 22 participants, 16 individuals had never heard about the Internet, let alone used it to research HIV-related information. Most participants (73%) had access to a television in their homes. Six participants (27%) had access to a video machine and three (13.64%) had access to a DVD player. Only one participant had access to a computer in her home, and this machine was not connected to the Internet.

Table 5-7: Demographic data related to subjects' general familiarity with technology. This includes computer usage and previous exposure, as well as access to other commonly available consumable hardware.

Variable	Yes		No	
	N	Percentage of Sample	N	Percentage of Sample
Previous computer usage	8	36 %	14	64 %
Internet knowledge	6	27 %	16	73 %
Access to **television** at home	16	73 %	5	23 %
Access to **video machine** at home	6	27 %	15	68 %
Access to a **DVD player** at home	3	14 %	18	82 %
Access to a **computer** at home	1	5 %	20	91 %

5.1.3 Overview of Statistical Tests

The basic experimental design underlying the research is a pre- posttest design in which participants were seen on three separate occasions. In this study, the number of participants in each of the three groups are five (text), eight (VE group) and nine (control group). Due to these small sample sizes, no assumptions can be made about the distribution of the data. Therefore, non-parametric statistical tests were chosen. Friedman's two-way ANOVA is the nonparametric alternative to repeated measures ANOVA and can be used in pre- post-test experiments. It is used in this study, to investigate all dependent variables making up the *Dietary Quality* and *Food Safety Knowledge* concepts (introduced in Sections 4.4 and 4.3 respectively). Although the number of comparisons that were performed does inflate the

likelihood of Type 1 error, these statistical tests are the most appropriate with the available data. For example, we could do a Bonferroni correction, but that would trivialise the value of having recruited such an externally valid sample.

The *Dietary Quality* concept is further divided into the following four sub-areas. These sub-areas are then translated into two dependent variables that are measured at the pre- and post-tests respectively. These variables are listed in parenthesis.

- Food Intake
  - Servings Score (*Pre Milk / Post Milk, Pre Energy / Post Energy, Pre Protein / Post Protein, Pre Fruit / Post Fruit, Pre Veg / Post Veg*)
  - Variety within diet (*Pre Variety Within / Post Variety Within*)
  - Variety among diet (*Pre Variety Among / Post Variety Among*)
- Water Intake (*Pre Water / Post Water*)
- Vitamin Intake (*Pre Vitamins / Post Vitamins*)
- Preventative Dietary Behaviours (*Pre Pumpkin / Post Pumpkin, Pre Carrots / Post Carrots* and *Pre Garlic / Post Garlic*)

5.1.4 Descriptive Statistics

The nonparametric descriptive statistics across all groups, for each of the dependent variables are presented below in two tables. In Table 5-8, the variables associated with the pre-test time of measurements are presented, and Table 5-9 shows the same measurements, taken at the post-test. Note that there were 22 experimental subjects that provided valid measurements. However, one participant was unable to produce scores for *Post Vitamins, Post Pumpkin, Post Carrots* and *Post Garlic*. The last columns in Table 5-8 and Table 5-9 show the maximum value that could be scored for each of the variables. The *Pre Energy, Post Energy, Pre Vitamins* and *Post Vitamins* variables deserve particular mention here since the medians observed in these four variables were the maximum score obtainable. Since participants had achieved the highest score possible, it was not possible to see improvements in these particular areas.

Table 5-8: Nonparametric descriptive statistics for all dependent variables, as measured at the pre-test: There are five variables relating to the food groups (*Pre Milk, Pre Energy, Pre Protein, Pre Fruit* and *Pre Veg*) and two variables measuring variety in the diet (*Pre Variety (Within)* and *Pre Variety (Among)*). Variables measuring water (*Pre Water*) and vitamin consumption (*Pre Vitamins*) are presented, and the three dietary behaviours *Pre Pumpkin, Pre Carrots* and *Pre Garlic*. The *Pre Energy* and *Pre Vitamins* medians are highlighted and in red, since they are the maximum score attainable.

Variable	Valid N	Mean	Median	Std. Dev.	Max
Pre Milk	22	3.71	4.01	2.57	10
Pre Energy	22	9.50	***10.00***	0.87	10
Pre Protein	22	7.17	7.96	2.77	10
Pre Fruit	22	3.61	2.53	2.94	10
Pre Veg	22	4.85	4.57	2.53	10
Pre Variety (Within)	22	1.91	1.67	1.25	5
Pre Variety (Among)	22	10.09	10.00	2.60	15
Pre Water	22	2.52	2.08	2.34	10
Pre Vitamins	22	0.91	*1.00*	0.29	1
Pre Pumpkin	22	0.01	0.00	0.02	5
Pre Carrots	22	2.50	2.50	2.00	5
Pre Garlic	22	0.43	0.00	0.79	5

Table 5-9: Nonparametric descriptive statistics for all dependent variables, as measured at the post-test: There are five variables relating to the food groups (*Post Milk, Post Energy, Post Protein, Post Fruit* and *Post Veg*) and two variables measuring variety in the diet (*Post Variety (Within)* and *Post Variety (Among)*). Variables measuring water (*Post Water*) and vitamin consumption (*Post Vitamins*) are presented, and the three dietary behaviours *Post Pumpkin, Post Carrots* and *Post Garlic*. The *Post Energy* and *Post Vitamins* medians are highlighted and in red, since they are the maximum scores attainable.

Variable	Valid N	Mean	Median	Std. Dev.	Max
Post Milk	22	4.11	3.75	2.57	10
Post Energy	22	9.44	***10.00***	0.87	10
Post Protein	22	6.71	6.63	2.77	10
Post Fruit	22	4.27	3.33	2.94	10
Post Veg	22	6.08	6.67	2.53	10
Post Variety (Within)	22	1.95	1.67	1.25	5
Post Variety (Among)	22	10.00	10.00	2.60	15
Post Water	22	1.78	2.08	2.34	10
Post Vitamins	21	0.76	*1.00*	0.29	1
Post Pumpkin	21	0.83	0.00	0.02	5
Post Carrots	21	3.45	5.00	2.00	5
Post Garlic	21	0.80	0.71	0.79	5

5.2 Dietary Quality

For this research, dietary quality consists of food, water and vitamin intake, and the three preventative dietary behaviours. In this section, we begin with the questionnaire used to gain an understanding of the challenges facing our participants in completing food diaries (the main method for capturing this data). Analyses for the dependent variables making up Dietary Quality are then presented.

5.2.1 Experiences Using Food Diaries

Since we assumed that the participants would be unfamiliar with capturing their daily food and beverage intake, seven questions were asked that explored the experiences and practises followed during the days of capture.

In the first question, we asked participants whether by having to capture their daily intakes, if they became more aware of their diet in general. Nineteen participants felt they did, and the remaining three individuals stated that it did not. These three participants elaborated stating that they just wrote it down, and didn't give it any other thought. The second question looked at the difficulties participants experienced in capturing this information. A majority stated that they did not find it difficult (20 out of 22). The remaining two individuals found it slightly difficult with one stating specifically that she had trouble remembering. With the third question, we asked participants to list the actual problems they had while completing the diaries. Fourteen participants did not have any problems, and eight did. Of these eight individuals, all stated that estimating measurements was the primary concern. In the fourth question, we looked at what items participants would include in their diet if money wasn't a concern. Four individuals were completely happy with their diet and would not add anything extra. With the remaining participants, the most common items for inclusion were more fruit and vegetables. Participants were requested to fill in the food diaries during the day, as they consumed the items. In the fifth question participants

gave an indication of when the food diaries were completed. The majority (20 of 22) completed it during the day (as recommended) and two participants completed theirs at the end of each day. In the sixth question, participants were asked whether they thought the food diaries were an accurate reflection of their food and beverage intakes. All participants stated that it was. In the final question, we aimed to gain an understanding of participants' financial resources available for food. Twelve participants stated that they often ran out of money for food, while nine stated that money was available.

5.2.2 Food Intake

For four of the five food groups under investigation, and for each of the two measures for dietary variety, three separate Friedman ANOVAs were conducted. These three tests corresponded to the three levels of the *Intervention* variable (that is, *VE*, *Text* and *Ctrl*). For each of these statistical tests, pre- and post-test scores for the particular food group or variety scores were compared. The firth food group that was not analysed was *Energy*. At the pre-test, most participants were already consuming the recommended minimum quantity of items from the *Energy* food group. The same finding was seen at the post-test for this variable (*Post Energy*). These variables are thus not suitable for statistical analysis. In total, 18 Friedman ANOVAs were conducted to measure changes in consumption of the five food groups and in terms of dietary variety. With these three specific tests for each food group, we were able to see whether any of the interventions produced a change in food intake in the participants. None of the 18 ANOVAs conducted, revealed a significant difference. Table 5-10 presents the statistical differences observed.

Table 5-10: Three separate Friedmann ANOVAs were conducted for each of the measures making up Food Intake. None of the results below are statistically significant.

	VE	*Text*	*Ctrl*
Pre Milk & Post Milk	Chi Sqr=0.0, df=1, p=1.000	Chi Sqr=0.20, df=1, p=0.655	Chi Sqr=0.143, df=1, p=0.705
Pre Protein & Post Protein	Chi Sqr=1.286, df=1, p=0.257	Chi Sqr=0.2, df=1, p=0.655	Chi Sqr=1.0, df=1, p=0.317
Pre Fruit & Post Fruit	Chi Sqr=0.0, df=1, p=1.000	Chi Sqr=0.2, df=1, p=0.655	Chi Sqr=0.5, df=1, p=0.480
Pre Veg & Post Veg	Chi Sqr=2.0, df=1, p=0.157	Chi Sqr=0.2, df=1, p=0.655	Chi Sqr=0.143, df=1, p=0.705
Pre Variety (Within) & Post Variety (Within)	Chi Sqr=0.5, df=1, p=0.480	Chi Sqr=0.2, df=1, p=0.655	Chi Sqr=2.0, df=1, p=0.157
Pre Variety (Among) & Post Variety (Among)	Chi Sqr=0.143, df=1, p=0.705	Chi Sqr=1.0, df=1, p=0.317	Chi Sqr=2.0, df=1, p=0.157

5.2.3 Water Intake

Pre- and post-test values for water intake were used in a Friedman ANOVA to test for changes in water consumption patterns following the intervention. As with the previous analyses (presented in Section 5.2.1), three ANOVAs were conducted (for each of the *Intervention* levels). No significant differences were observed in any of the three experimental groups: *VE* (Chi Sqr=4.5, df=1, p=0.304), *Txt* (Chi Sqr=1.0, df=1, p=0.317) and *Ctrl* (Chi Sqr=0.1, df=1, p=0.739).

5.2.4 Vitamin Intake

Remember that the two *Vitamin* variables measured the inclusion of any vitamin supplement in the participants' weekly dietary intake. As with the two *Energy* variables, most

participants were already consuming vitamin supplements prior to the therapeutic intervention being introduced (the median was the maximum available score). The same result was seen at the post-test. Because of this, it was not sensible to conduct analyses on these variables, especially considering the small sample size. Moreover, the participants making up the *Text* experiment group showed no variance within the *Pre Vitamin* and *Post Vitamin* variables — further evidence for not conducting analyses of these two variables.

5.2.5 Preventative Behaviours Data

Three specific dietary behaviours that alleviate potential stomach problems for HIV+ individuals were presented in the intervention. These three behaviours are reflected in three variable sets: *Pumpkin, Carrots* and *Garlic*.

1 *Pre Pumpkin and Post Pumpkin*

Three ANOVAs were conducted for the *Pre Pumpkin* and *Post Pumpkin* variables. These corresponded to the three levels of the *Intervention* variable. In these three tests, no statistical differences were found between the pre and post scores for pumpkin: *VE* (Chi Sqr=3.0, df=1, p=0.083), *Txt* (Chi Sqr=1.0, df=1, p=0.317) and *Ctrl* (Chi Sqr=1.0, df=1, p=0.317). The result observed in the ANOVA conducted on participants that experienced the VE, was interesting however. Although not significant, the result did suggest a trend towards an improvement in the consumption of the recommended food item and quantity. Note that the mean for this group was 0 at the pre-test and this affects the statistical test. That is, all participants from the VE group were not consuming any pumpkin seeds prior to the intervention. This resulted in no variance on the *Pre Pumpkin* variable. At the post-test, two individuals received the maximum possible score on the measurement scale (5) and another *VE* participant was consuming half the recommended amount (2.5). The lack of variance observed in the *Pre Pumpkin* variable, coupled with the small sample size makes statistical analyses difficult to interpret.

2 *Pre Carrots* and *Post Carrots*

Out of the three ANOVAs conducted for the *Pre Carrots* and *Post Carrots* variables, only the *VE* participants that experienced the VE showed a significant change in their consumption of the recommended food item and quantity (Chi Sqr=5.0, df=1, p=0.025). In Figure 5-1 a box and whisker plot is presented indicating this result. The two ANOVAs conducted for the *Text* (Chi Sqr=0.0, df=1, p=1.000) and *Ctrl* (Chi Sqr=3.0, df=1, p=0.083) groups showed no significant differences.

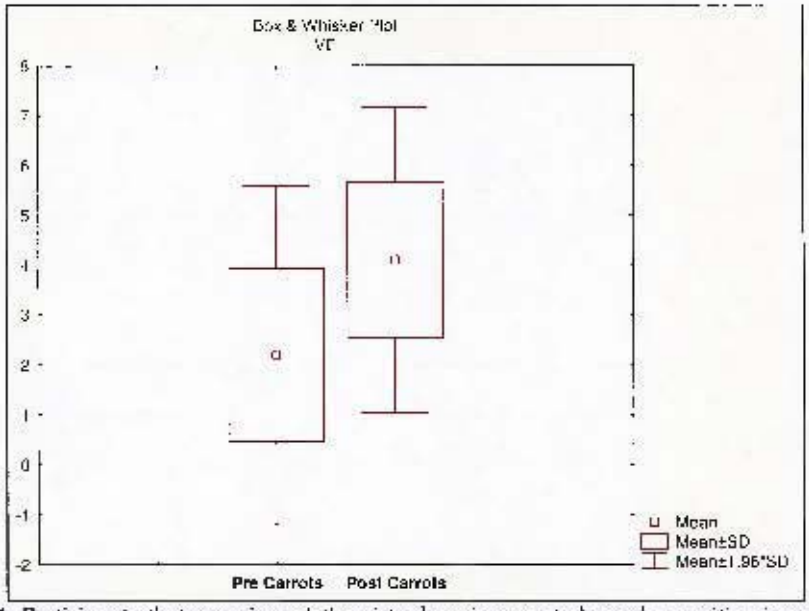


Figure 5-1: Participants that experienced the virtual environment showed a positive increase in the consumption of carrots. The result was significant (Chi Sqr=5.0, df=1, p=0.025).

3 *Pre Garlic* and *Post Garlic*

Out of the three ANOVAs conducted for the *Pre Garlic* and *Post Garlic* variables, only those participants that experienced the VE showed a significant change in their consumption of the recommended food item and quantity (Chi Sqr=6.0, df=1, p=0.014). In Figure 5-2 a box and whisker plot is presented indicating this result. The two ANOVAs conducted for the *Text* (Chi Sqr=2.0, df=1, p=0.157) and *Ctrl* (Chi Sqr=0.0, df=1, p=1.000) groups showed no significant differences.

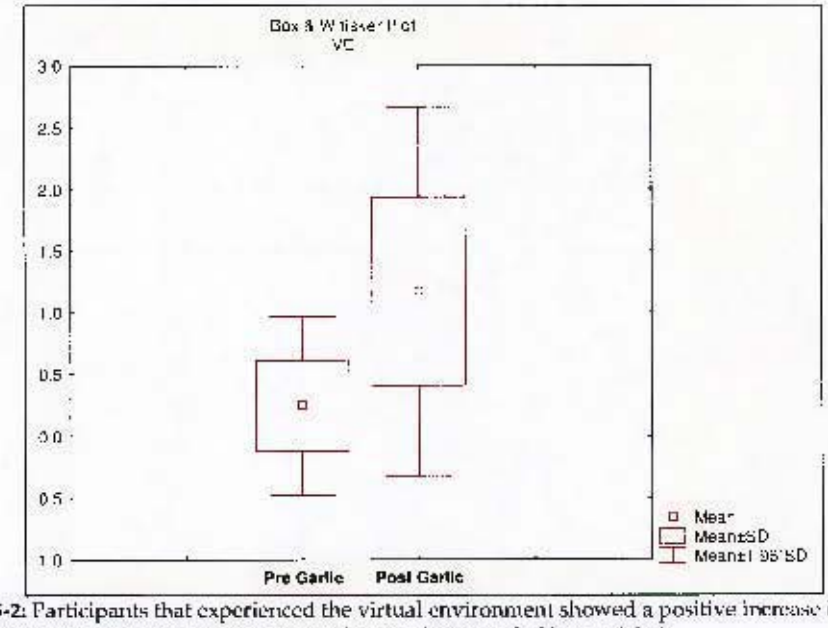


Figure 5-2: Participants that experienced the virtual environment showed a positive increase in the consumption of garlic. The result was significant (Chi Sqr=6.0, df=1, p=0.014).

5.3 Food Safety Knowledge

The data for the food safety knowledge variables was taken from the modified Food Safety Knowledge questionnaire (discussed in Section 4.3 and presented in Appendix B1). We look at item difficulty and test retest reliability as applied to the participants in this research study.

5.3.1 Food Safety Questionnaire – Item Difficulty

In the design and development of the original questionnaire, Medeiros and her colleagues measured item difficulty for each questionnaire item. They state that at the pre-test, between 20% and 80% of respondents should answer each question correctly. Using this criterion, they found that in their population samples, six items were considered too easy, and one item was considered too difficult.

Table 5-12 below presents the difficulty scores for each of the questionnaire items used in this research study. These items encompassed all those in the original scale, bar the six excluded items (presented in Table 5-11). The corresponding difficulty percentage calculated during the initial design and development of the original questionnaire [80] is presented alongside this data. Those items that were deemed too easy (above 80%) or too difficult (below 20%) are highlighted.

Table 5-11: Item difficulty of the questionnaire items used to measure participants' knowledge of food safety behaviours. The items that were considered too easy (above 80%) or too difficult (20%) are highlighted in red. The difficulties experienced by participants from this research study are presented alongside the difficulty percentages obtained during the design and development of the original questionnaire.

Questionnaire Item	Pre-Test Percentage Correct	Original Questionnaire [80]
1	95%	100%
2	55%	62%
3	36%	92%
4	64%	95%
5	9%	88%
6	45%	82%
7	50%	48%
8	23%	82%
9	68%	79%
10	36%	46%
11	64%	39%
12	59%	75%
Average	**50%**	**74%**

The fifth questionnaire item stands out from all the others: Only 9% of the HIV+ South African participants answered this correctly, compared to 88% of the American sample. The questionnaire item is presented below:

> *If you use a dishcloth to wipe up liquid from meat or chicken you can safely continue to use the cloth for washing dishes if you rinse the dishcloth in hot water.*

This is a reversed question and can be confusing if English is not your primary language. This was the case with our sample: only one out of 22 participants stated English as their home language. Therefore it was excluded from the summation, leaving the remaining eleven items to make up the *Food Safety* score.

5.3.2 Food Safety Questionnaire – Reliability

Knowledge questionnaires can be assessed by investigating the test retest reliability of the scale. This is done by administering the same questionnaire to a group of participants at different points in time. The higher the correlation between the variables, the greater the test retest reliability of the instrument [96]. A minimum correlation coefficient of 0.7 is required for an instrument to have good test-retest reliability [96]. In this study, only participants that were placed in the *Ctrl* group were used in these comparisons. Participants in the *VE* or *Text* groups cannot be used since the interventions experienced (either viewing the VE or reading the text pamphlet) have the potential to alter the scores obtained at the post-test. In Table 5.12, the correlation coefficient observed for each of the items in the Food Safety Knowledge questionnaire is presented. Only one (*Pre FS12* and *Post FS12*) of the eleven items showed a significant correlation (0.76, $p<0.05$). Although 10 of the 11 items had low test- retest reliability, a large part of this can be attributed to the small sample size (n=9).

Table 5-12: Correlation coefficients observed for each of the eleven items used in the Food Safety Knowledge questionnaire (using participants from the *Ctrl* group). The only significant correlation was found with the last item in the scale, *Pre FS12* and *Post FS12*, is highlighted in red (0.76, $p<0.05$).

Pre-test Variable	Post-test Variable	Correlation
Pre FS1	*Post FS1*	0.40
Pre FS2	*Post FS2*	0.32
Pre FS3	*Post FS3*	0.50
Pre FS4	*Post FS4*	-0.00
Pre FS6	*Post FS6*	0.32
Pre FS7	*Post FS7*	0.10
Pre FS8	*Post FS8*	-0.32
Pre FS9	*Post FS9*	0.00
Pre FS10	*Post FS10*	0.50
Pre FS11	*Post FS11*	0. 19
Pre FS12	*Post FS12*	**0.76**

5.3.3 Changes in Food Safety Knowledge

Although there were some concerns raised regarding the suitability of the Food Safety Knowledge questionnaire, we feel that the results obtained from its usage can still be examined. While bearing in mind the low reliability observed, pre- post-test experimental designs are more lenient towards such identified problems, since the same scale is administered at both test times. This way, a participant is compared against themselves and any extraneous variable (such as primary language) would not change between the two experimental meetings. Additionally, although internal validity is particularly low in this sample of participants, the external validity is strong: the subjects involved in this study are representative of the targeted end-users of such an intervention. That is, people infected with HIV, living in South Africa.

In order to test whether a change in knowledge of food safety occurred in any of the experimental groups, three separate Friedmann's two-way ANOVA were done. The total knowledge score was a summation of all the individual items (marked as 1 for correct, and 0 for an incorrect answer). However, the fifth item was excluded in this summation score due to item difficulty. This resulted in a *Food Safety Knowledge* score ranging from 0 to 11 (all questions answered correctly). No significant differences between the pre and post-test scores were observed: *VE* (Chi Sqr=0.67, df=1, p=0.414), *Txt* (Chi Sqr=0.0, df=1, p=1.000) and *Ctrl* (Chi Sqr=0.143, df=1, p=0.705).

5.4 Participants' VE Experiences

Semi-structured interviews were conducted with the nine participants immediately after they experienced the VE. The interviews were recorded and later transcribed. A content analysis was then conducted on these interviews, and the following three themes emerged. These were the quality of the information, ease of use of the system, and accessibility of the information.

5.4.1 Quality of Information

Almost all of the participants (one exception) said they felt excited about the amount and quality of the information presented by the system.

> *"About the information I was so excited. Because I heard everything that I need to hear and aarr, they explained everything so clearly. Everything is clear there, loud. So I don't, I don't complain"*

All agreed that the information was useful to them with the majority stating that they had learnt something new. One participant in particular said that the system highlighted for her how much she still needed to learn.

> *"It was exciting because it teaches me a lot. And um, I thought before I knew everything, but I noticed now, I still have to learn more. Ja, a lot more"*

> *"Because she's* [Sandi, the virtual character in the kitchen] *given me most of the information that I didn't know about. And she's given me that as well. And some of the stuff I knew about but I just didn't know what the reason behind them. Whether to use them, whether to eat them, or things like that. Things like that."*

> *"You learn a lot of things. The thing that you think you know, but some you don't know. Ja then you get to show them."*

> *"the people were talking. There I've gained a lot. And the nutrition, nutritional food. I've gained a lot. There was a lot in that room."*

> *"The people in the house – they taught me a lot. Um ... the Jik* [a bottle of bleach in kitchen] *there ... and then the lounge, talking about their problems and ... So the people inside the house were great. Um ja, ja, but I've learnt a lot from the, from Sindi* [Sandi, the virtual character in the kitchen] *and the kitchen. I've learnt a lot from her because ... er, that's where that I'm not quite clued up when it comes to nutrition."*

Participants expressed a definite need for general HIV-related information. One participant who worked in a government hospital explained:

> *"we are talking with those mothers every day, or every week, I think we need to show them and this is not right for you. Not just telling them. But if we can have some posters, I think that will be good for them"*

> *"Some of the information is available – like hospitals. It's not like everywhere – it's not all the information. Because um ... sometimes you hear like on the radio because I remember hearing about the part about garlic on the radio and it depends on which problem you are."*

And, one participant specifically identified the informational content, and not the VE or computer system, and gave it a higher importance, compared to the physical content, aesthetics and the computer.

> *"For me, the house ... ja, the house was nice but er, that was not it for me. I mean, I was more focused at what they had to say than looking around the house, seeing the bedroom and all this ... what they had to say, y'know? So I was mostly concerned with what they had to tell me ... than the house.*

All participants agreed that the information in the system would be of great help, and should be presented soon after an HIV+ diagnosis. However, there was some disagreement as to what the time frame should be. Two (of the nine participants) would have wanted to see the system immediately after diagnosis; while the other seven women stated they would prefer to have reached some degree of acceptance of their status before the system should be introduced. In support of this:

> *"Ja, because it reminded me of the things that I'm supposed to be doing. And I think on my first counseling, the first time I was counseled, each and every thing was mentioned at the clinic but it looks like I've lost some of the things during it"*

5.4.2 Ease of Use of the System

Half of the *VE* participants had used a computer before this study. However it should be noted that at the beginning of the experiments, when assignment into experimental groups occurred, only those participants that were comfortable with the idea of using a computer were placed in the *VE* group. This may affect the relative high proportion of prior computing exposure in the sample, as compared to the rest of the experiment sample. Of those five participants that had prior computer experience, only two had used the Internet, and only one had used it to search for information on HIV. This particular individual then explained that it had only happened once or twice, and that it was a colleague who had searched, downloaded and printed the HIV related information:

> *"Well, most of the times she, she does the whole thing. Then I just look because er, that's her own space, it's where she works, y'know? I have to respect that. I want to, y'know, but she searches for all the information"*

Despite this minimal prior exposure to computer, every participant reported that the system was easy to use. However, some did express some anxiety at using or possibly damaging the equipment during the early phases of their experience.

> *"At first I was not so comfortable. But the time goes on, I practice to, to be comfortable. And as a result I end up so comfortable and so interested about this mouse"*

> *"Mmm, I was nervous – it was not difficult – I was nervous"*

> *"Before it was uneasy with the mouse to move, like, I was a bit tight ... But now with the ... er ... like when I'm getting on, then it's fine"*

The ease of use is corroborated by the overall impressions given of the system. All participants found the system useful, and about half stated that they found it exciting. About the same number mentioned that they enjoyed the freedom afforded by walking around the VE and being able to choose the information they wanted.

> *"It was quite flexible ... flexible like it allows you to go in, to go out. And I was able to move around as well"*

"It was great, because I was a given, what, options? Options to ... for what I want ... where you have all the information. What I wanted to know they giving me options to find exactly that. You can stop and look at what you want to look at. It's great."

5.4.3 Accessibility of Information

The ease of use of the system suggested that the information was highly accessible to our target population. We asked participants if they would return on their own to use the system if it were deployed in clinics. Without exception, all participants responded that they would return to use the system if it were available.

"Of course! Yes! Because this was so interesting to me. And I was going to need, what I missed and what I didn't see that time. So I was going to go everyday to the computer and check what is going on today, what they introducing. Ja"

"Yoh, <laughs happily> I would be glu-ed in the computer. Really I would. I will be interested; to work with it ... I would love it!"

However, one participant highlighted an important practical barrier to the use of VR system, and highlighted the availability of television as a communication medium:

"Ja, but we don't all have access to computers and also to videos. We don't have enough money to buy those things. But even if the TVs black and white, if they got it, they use it ... And even if it's twice a week. Maybe you are doing it on Monday, then you are repeating the episode on Tuesday, maybe in the evening. Then you are going to see what was happening on Monday. Then you are going to, to do another, another session on Wednesday. Then you are going to repeat that session on Thursday. I think that will be useful"

Another interest observation was made by some participants regarding the individualised nature of this particular desktop VE. The use of headphones during the VR experience encouraged this idea, suggesting that only one individual could benefit from the lengthy VE at a time. However, when a speaker system was suggested, there was considerably more interest.

"Because now the computer ... have to have your earphones – one person listening at a time. Fortunately we never had that, like we can't offer that to patients because people sometimes in a hurry, they come and go. Some people, they want to come and see and do both things, like everybody watching, but the video is something you can put. Maybe sometimes for those who even, haven't spoken to about their status to somebody else. They can also watch and gain information and keep it for themselves and use it."

Interestingly, when asked if the system could replace the function of a peer-support group, most participants expressed that the system would make a good adjunct to a peer-support group, for providing more specific information. When asked if this type of information was difficult for them to find, most agreed that it was easy to get though their counsellors. This suggests that in areas where counselling support is limited, the system may be particularly useful.

In general, we found that while the interface presents no problem, the volume of information should be vastly increased – in the average 28 minute session, each participant selected and listened to all of the available information, and more than half specifically mentioned that they would like to see the amount and variety of information in the system increased.

> *"So like if I had to have the whole day* [to sit at the computer], *then her* [Sandi in the kitchen] *packing with some stuff packed so, her to explain more. I'd enjoy it. You see those, those bowls, those things packed there. I feel she can add more stuff and keep on explaining to me."*

However, one participant did describe the information quantity as overwhelming. However, remember that participants at this point in the interview may not have known that they would be given a textual pamphlet of the content and this participant may have felt pressure to remember as much of the informational content as possible. Interestingly, this participant did choose to view every possible interaction within the VE.

> *"It kind of overwhelmed me. I don't know ... er ... I think maybe ... the house itself was quite comfortable house. And ... the knowledge ... it was more information that I expected."*

5.5 Chapter Summary

In this results chapter, we began with descriptive statistics that described some basic characteristics of the 22 individuals making up our sample. These participants were placed into one of three experimental groups, and these groups differed on the intervention experienced. One group of participants experienced an information-rich VE, and the second group were given a comprehensive pamphlet to read, comprising of the content found in the VE. The third group of participants acted as the control group. In this research, we investigated two separate concepts: *Food Safety* and *Dietary Quality*. The results obtained for each experimental group in these two areas were presented. There were no significant differences between the three experimental groups for the *Food Safety* and *Dietary Quality* (intake of food, water and vitamins) concepts. Within *Dietary Quality*, we saw a significant change in the two of the three *Preventative Behaviours* variables for the *VE* participants only. We conclude this chapter with three themes arising out of interviews conducted with participants who experienced the VE. The following chapter is the discussion of the results. In it, we use the statistical results presented here, to answer the research questions governing this study.

Chapter 6

Discussion of Results

We now proceed with a discussion of the results presented in the previous chapter. We start by looking at the two research questions underlying this work and test the four hypotheses (presented in Section 1.3). We conclude this chapter by looking at the themes identified during the content analysis of interviews conducted with participants that experienced the VE.

6.1 The Research Questions

The first research question addresses the ability of VR to deliver informational support to people living with HIV/Aids. The second research question looks at whether the VR medium is better at delivering informational content to its audience, compared to traditional booklets (see Section 1.3)

For each of these questions, we test two hypotheses: The first focuses on changes in the quality of participants' dietary intake (*Dietary Quality*), while the second looks at changes in participants' knowledge of food safety behaviours (*Food Safety Knowledge*).

For the two hypotheses making up the first research question, we limited our analyses to those participants that were placed in the *VE* experimental group, and we looked at whether those participants showed individual improvements. That is, we were interested in whether individuals who experienced an information-rich VE would show improvements in the two specific areas. If both these hypotheses are found to be true, then VR can be viewed as an effective communication medium for the provision of informational support to HIV+ people.

In the third and fourth hypotheses (that make up the second research question), we compare the three experimental groups of *VE*, *Text* and *Ctrl* (see Section 4.2). If the VE participants show improvements in the two areas, statistically more than those participants making up the *Text* and *Ctrl* groups, we would be able to state that VEs are indeed better than booklets, in terms of delivering informational support to its audience / readers.

6.2 Hypothesis 1: An HIV+ person who experiences a VE rich in nutrition information will show an improvement in their dietary quality

As stated in Section 5.2, dietary quality consisted of four categories (*Food Intake, Water Intake, Vitamin Intake* and *Preventative Dietary Behaviours*). A discussion of the results obtained from each of these individual areas is now presented.

6.2.1 Food Intake (Milk, Energy, Fruit, Veg, Protein and Variety)

Intake of five different healthy food groups consumed as well as dietary variety was explored. No significant improvements were found in any of the five food groups. That is, participants that experienced the VE did not exhibit a significant improvement in their daily consumption of the minimum recommended amount of items in each of the five food groups. Note that in four of the five food groups, the VE participants did *not* consume the minimum recommended number of food items at the pre-test, that is, before the intervention was introduced. It is important to state this, as we were investigating *improvements* in consumption of food group items. Using this measure, it is only possible to see improvements if individuals were **not** already consuming the recommended minimum amounts.

The one exception to this was the *Energy* food group: the median for this food item was the maximum available score, making it unsuitable for statistical analysis. That is, prior to the intervention most participants were already consuming the recommended minimum amount of items from this food group. This observation has been found in other studies on nutritional status of South Africans, and can be attributed to the staple maize products typically found in the South African diet [97].

With respect to the variety measures, we did not see significant changes in the two ANOVAs conducted for diet variety (both within and among food groups) for participants placed in the VE group (see Section 5.2.1). For both measures, those participants that experienced the VE did *not* have an adequate measure of variety within their diets prior to the intervention, and it was hypothesized that experiencing an information-rich VE would improve this. This hypothesis was not supported.

6.2.2 Water Intake

As presented in Section 5.2.3, no significant improvements were found here and prior to the intervention, participants were not consuming the recommended minimum amount of water. For consumption of some items such as meat, it is clear that a lack of finance would have some effect in the inclusion of the item into an individuals' diet, but this is not the case for water consumption since water is freely available in South Africa. Drinking the correct amount of water however, is one habit that people know is good to have, but most find hard to fulfil. That is, there aren't many people (regardless of their HIV status) who do in fact drink the recommended eight glasses of water on a daily basis. The experiment also took place in the cooler months of Cape Town which does affect water consumption.

6.2.3 Vitamin Intake

As with the *Energy* food group, participants that viewed the VE were already consuming vitamin supplements prior to experiencing the VE. An interesting observation from this data however, is the source of the actual vitamins reportedly consumed. With the exception of one participant, all participants received their vitamin supplements from government clinics. The nutritional support presented in the two interventions encouraged individuals to consume specific vitamins and provided advice on the cheapest method of obtaining them. For the many participants that received vitamin supplements from government clinics within our sample, it can be assumed that their available budget for additional vitamins would be minimal, if any. Remember that more than half of all participants (12 out of 22) reported that they ran out of money for food (see Section 5.2.1). Additionally, it is likely that participants, who were already receiving vitamin supplements from government clinics, would be less motivated to obtain additional items if they felt confident with their current supplement. Any additional available funds would more likely be given to other living expenses. The two variables for measuring vitamin consumption (*Pre Vitamins* and *Post Vitamins*) were dichotomous in that participants either consumed supplementary vitamins in the previous week, or they did not. Because of this, the two variables did show a ceiling effect in that most participants did consume some form of vitamin supplement (predominantly from the government health clinics), and thus received the maximum score for the variables.

6.2.4 Preventative Dietary Behaviours

The three preventative dietary behaviours consisted of the consumption of three specific food items. There was a statistically significant improvement in two of the three recommended items (consumption of specific quantities of carrots and garlic) for participants that viewed the VE. There was no significant difference with the third food item, which was the consumption of dried-out pumpkin seeds. However there was a marked increase in the consumption of this food item (although not statistically significant), and this was similar to the significant positive increase observed with the first two preventative dietary behaviours (consumption of garlic and carrots). Pumpkin seeds are not a common dietary intake in South Africa and since none of the *VE* participants were consuming them prior to the intervention, it can be assumed that participants were just unaware of their importance. Although not significant, there was an increase – from none before to three individuals (out of eight) eating them after the VE intervention. Only those participants that experienced the VE showed the improvements in two of the three preventative dietary behaviours.

It should also be noted here, that the sample sizes used in the study were very small. The number of individuals placed in the *VE*, *Text* and *Ctrl* were eight, five and nine respectively. These small sample sizes, coupled with the fact that the number of participants in each of the groups was unequal, do affect any statistical analyses conducted and should be considered when examining these results. Bearing in mind that there were significant results observed, the study should be repeated with a larger sample.

From the statistical analyses performed on the above dependent variables, the only significant results obtained related to changing specific dietary behaviours aimed at preventing stomach complaints. The hypothesis that HIV+ people who experience a VE will show improvements in dietary quality was only proved true for these two specific dietary behaviours. Experiencing a VE did not have the desired effect of improving participants' general eating habits as expected. However, there are a number of issues that could account for this:

Although effort was made to ensure that dietary recommendations always specifically stated the cheapest methods for incorporating the items into participants' diets, changing a diet requires some monetary input. The extremely low average household income of our sample most likely impacted on their ability to purchase healthier foods or to change their eating habits. As evidence for this, the vitamins participants could afford were provided through government clinic. Additionally, most participants specifically stated that they regularly ran out of money for food (see Section 5.2.1).

Another potential impacting factor is the actual use of food diaries as the method for data capture. The accuracy of data capture in food diaries is generally increased if participants use actual measurement scales and record very specific amounts. This was not possible for our research — we did not want to draw attention to our participants and ask them to keep a food measurement scale on them. The stigma surrounding HIV infection in South Africa is an important concern here. Therefore, it is possible that there were some errors and inaccuracies when participants captured the quantities consumed. These errors may have hidden smaller effects within the statistical analyses.

For the dietary behaviour recommendations, a significant positive result was observed in the VE participants for two of the three recommendations. We posit four reasons for this effect.

If we look at the physical placement of the recommendations within the VE, they were positioned in the opposite corner to the food group section. This placement could possibly have assisted participants in isolating them, thereby making them easier to remember.

Related to this, was the order of the content experienced by the *VE* participants. Usually, the order in which users experience the content within a VE is dependent on the decisions made by the user during the VR experience. In the VE used for this research, avatars were used to give introductions to the different areas of interest. In the virtual kitchen, this avatar introduced the different sections, in the order depicted in Figure 6-1 below. When the user entered the kitchen, they were told of the two broad areas within the room. In this introduction the user was first told about the *Food Groups* section, followed by a basic description of the *Cleanliness & Hygiene* section. After this introductory session, the user had to choose which area to experience first. All *VE* participants choose to experience these two sections in the order they were introduced. Within the *Food Groups* section, no order was given for each of the food groups, and each user choose a different order when selecting which food group to experience. However, within the *Cleanliness and Hygiene* section, the kitchen avatar introduced the three sub-sections in the order shown below in Figure 6-1. All *VE* participants followed this order, making the *Clean Stomach* section the last scene experience by all *VE* participants. This sub-section contained the three dietary behaviours – where the significant improvements in two of these were observed.

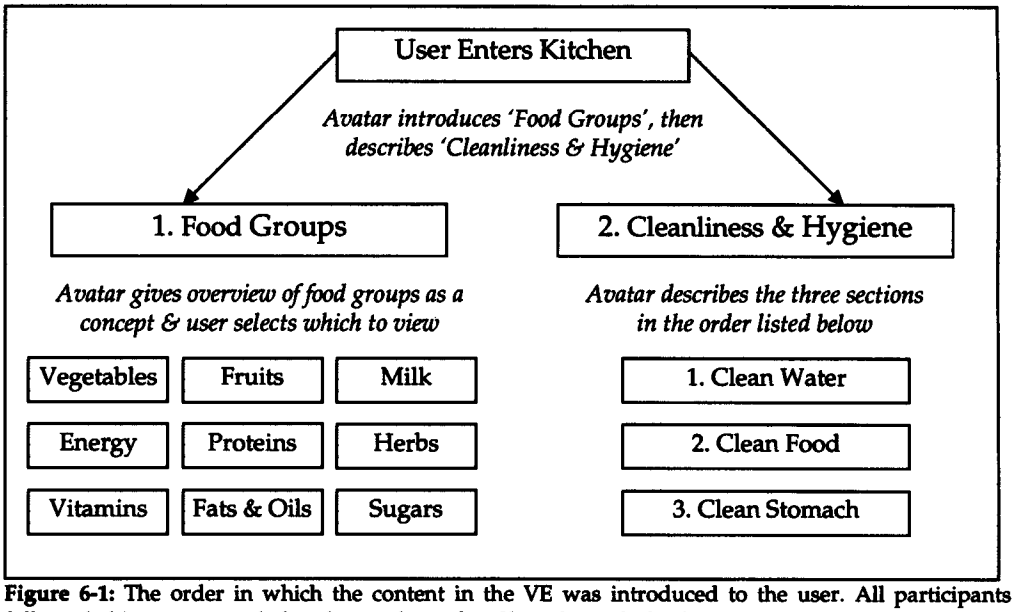


Figure 6-1: The order in which the content in the VE was introduced to the user. All participants followed this recommended order, making the *Clean Stomach* the last area experienced within the environment.

There was a large amount of information presented in the VE, and the mean time spent in the environment was 28 minutes. Although all VE participants were given a textual pamphlet of the content to take home with them, it is possible that some of the large quantity of information was lost and/or was difficult to remember. With the dietary behaviours being the last viewed area within the VE, it is likely that they were more easily remembered. This is known as a *recency effect* and is often coupled with a *primary effect*: If one is given a list of items to remember, one is more likely to remember the first and last entries, than the ones placed in the middle of the list. In this work, there is no primary effect in the kitchen: the first area participants navigated towards was the *Food Groups* section. This however was divided into nine different sub-sections, and each participant chose a different group to experience as their first food group of interest. If participants experienced a primary effect within the kitchen scene, it would not show up in the analyses. A primary effect could however, present itself in the virtual support group as this was the first scene that the user experienced inside the virtual house. Three out of the eight subjects who viewed the VE specifically mentioned their interest in this particular scene and rated it as one of the most important.

> *"Okay, she enjoyed the people, the 3 people sitting in the lounge chatting to one another"*
> [Translated interview]

> *"and then the lounge, talking about their problems ... so the people inside the house were great."*

> *"something I did like is that they're open about their status. And they are having some sort of a support group there where they empower the others and they share their feelings with the others so that, even if, you are not their colleagues, they're still afraid they must know what to do and not to know."*

However, the fact that the *VE* participants who viewed the VE showed a positive improvement in the consumption of the two (of three) food items related to preventative dietary behaviours and the fact that this information was experienced last, could also show an experimental order effect. If one were to repeat this experiment, it would be useful to

counterbalance the order of information by balancing the order of presentation in order to further understand this possible effect.

Another convincing reason for the results obtained in this area is the *minimal number* of behaviour recommendations. There were only three, and it is easier to focus on changing a smaller number of items in your daily activities. A major change in diet that includes more balanced meals, takes a lot more effort and attention. Evidence for this is the multi-billion dollar dieting industry typical of the western world and how difficult it is for many people to change their dietary intake. A fourth possible explanation is that the success of the recommended dietary behaviours is financially motivated. The recommended items are a cheap addition to the daily food intake of participants, and the items are also accessible, and commonly found in South African supermarkets and shops.

6.3 Hypothesis 2: An HIV+ person who experiences a VE rich in nutrition information will show an improvement in their knowledge of food safety issues

Within the group of participants that experienced the VE, no significant improvements were observed in participants' knowledge of food safety behaviours.

We cannot draw major conclusions about the impact of the VE in this area, but it is important to reexamine the chosen measurement scale and assess its suitability. During the development and design of the original food safety questionnaire, the scale was tested with population samples in the Washington State of the United States of America [80]. There was some concern on its suitability for a South African audience.

An important concern that deserves mention is the difficulty with which our participants completed the questionnaire. Most questionnaire items were within the recommended difficulty range in that between 20% and 80% of individuals participating should answer them correctly. However, when compared against the American sample who took part in the initial design and development of the original questionnaire [80], a considerable lesser percentage of our participants accurately answered the questionnaire items. Medeiros and her colleagues acknowledge that while the questionnaire was designed with a broad variety of audiences in mind, it had not been administered and tested on people who did not have English as their first language, and also individuals with low reading skills [80]. This surely affected the South African participants' ability to answer the questionnaire in a way that completely and accurately reflected their knowledge of food safety behaviours. At the end of the study, the experimenter went through the questionnaire with all participants, giving the correct answers and explanations. During this time, one participant specifically mentioned that she didn't understand the question initially, and if more explanation had been provided, she would have answered it differently.

In analysing the reliability of the Food Safety Knowledge questionnaire used in this research study, only one of the twelve items had an acceptable correlation. However, with such a small sample size, the correlations that were observed are unstable, making them difficult to infer reliability accurately. If this study were to be repeated with a larger sample, a better estimate of reliability would be seen.

6.4 Answering Research Question One

The first research question looks at whether VEs are effective in providing informational support to individuals infected with HIV. We examined this by looking at a number of dependent variables relating to both participants dietary quality and their knowledge of food safety behaviours. Using a pre- post-test experimental design with the informational VE introduced as the therapeutic intervention, participants' results in the dependent variables measured before the VE experience were compared against those taken after the intervention. For the subjects that experienced the VE, we did not see a significant improvement in knowledge of food safety behaviours. However, there were some major concerns relating to its suitability and appropriateness for a South African population sample (see Section 5.3). Note that the sample used for this research was representative of the target users for such a system (i.e. South African women infected with HIV) but the questionnaire was not appropriate. With these same VE participants, we also did not see any significant improvements in the consumption of most of the variables making up the *Dietary Quality* measure. These were *Food Intake* (including five food groups and two variety scores), *Water Intake* and *Vitamin Intake*. An important observation here though, is the measurement scales used looked at whether participants consumed a minimum recommended quantity of items in each of the categories. For the *Energy* food group and the *Vitamin Intake*, a ceiling effect was observed in that most participants were already consuming the recommended minimum quantity prior to the intervention. It is thus not possible to see improvements within these two categories.

The final category making up the *Dietary Quality* measurement consisted of three dietary behaviours that were specifically recommended for the prevention of common HIV-related infections (*Preventative Dietary Behaviours*). These were the consumption of dried-out pumpkin seeds, garlic and carrots. Interestingly, all participants that experienced the VE saw positive significant improvements in the consumption of two of the three food items (garlic and carrots).

With this in mind, we cannot say that experiencing a VE was effective in providing informational support in the area of food safety nor all of the categories making up dietary quality. However, the positive improvements shown by the participants that experienced the VE in two of the three preventative dietary behaviours are very promising. The study should be repeated with a larger sample.

6.5 Hypothesis 3: An HIV+ person who experiences a VE rich in nutrition information will show more improvements in their dietary quality than an HIV+ person who experiences the same content presented in a booklet

Remember that the *Dietary Quality* concept was categorised into four different areas: *Food Intake, Water Intake, Vitamin Intake* and *Preventative Dietary Behaviours*. Statistical analyses were conducted on all separate experiment groups for all dependent variables defined for this research, and no statistical improvements were observed in the *Text* and *Ctrl* groups in the area of *Dietary Quality*.

The only significant difference obtained in all of the quantitative analyses for the *Dietary Quality*, within all experimental groups, was that of the *Preventative Dietary Behaviours*. It was found that participants who viewed the VE were the only subjects who showed any change

in two of the three specific dietary behaviours (those being the consumption of garlic and carrots). These food items are specifically recommended for HIV+ individuals to assist with the prevention of stomach complaints [59]. The VE group showed a positive improvement in the consumption of two of these three food items, in comparison with the *Text* and *Ctrl* groups. Thus overall, we cannot conclusively say that VEs are better than booklets for the delivery of informational support. However, the VR medium was better at delivering the three specific dietary recommendations and this is an important result that deserves further investigation. With the small sample size of this study, a statistically significant result is relatively difficult to achieve.

To understand why the positive results were observed with the *Preventative Dietary Behaviours* in the *VE* participants, we need to examine the two different types of communication media. The booklet (see Appendix C) contained all information presented in the environment, and both text and images were used throughout. Screenshots were taken of each scene within the VE for this document. Because of this, the visual aspects of a VR simulation could not account for the differences observed between the different experiment groups. However, a major difference between the two media is the animations and voices associated with each of the virtual characters. Aspects of interpersonal communication such as tone of voice, conversational pauses and body language all aide in creating a personified virtual character to which users could relate. Pauses within the dialogue may also make it easier for participants to absorb such information. Additionally, eye contact is an important aspect of interpersonal communication, and the virtual character was always rotated to face the user within the VE.

A great deal of effort was placed in creating an environment that was realistic, comfortable, accurate and relevant to our South African novice computer users. The accommodating warm environment, combined with the motivational virtual actors may have made the participants more comfortable and thus more susceptible to absorb information, as compared to those participants who read a booklet of the same content.

Remember that the majority of participants listed isiXhosa as their home language (21 of 22), and the only other participant stated Afrikaans as her primary language. Reading skills are often better in one's primary language, and since the booklet was presented in English, participants may have found it more difficult to read the informational content in their secondary, sometimes tertiary language, rather than listening to the same information in a visually and auditory stimulating environment. This could definitely have resulted in more positive results as observed in the *VE* participants.

6.6 Hypothesis 4: An HIV+ person who experiences a VE rich in nutrition information will show more improvements in their knowledge of food safety behaviours than an HIV+ person who experiences the same content presented in a booklet

The participants making up the *Text* and *Ctrl* groups did not show any significant improvements in their knowledge of food safety behaviours. However, neither did those participants making up the third experiment group (*VE*). We mention above in Section **Error! Reference source not found.** when answering hypothesis 3 that the VE is more effective as a communication medium due to it being a richer medium, using voice and animation making the user more engaged with the content. We would expect to see a similar result for participants' knowledge of food safety before and after experiencing the VE intervention. However, as we have discussed in Section **Error! Reference source not found.**

there were concerns regarding the suitability of the questionnaire used to measure this variable in our particular South African sample of HIV+ women. Language played a role here (no participants listed English as their primary language) as well as cultural differences. Because of this, we cannot say that VEs were more effective (than the paper medium) in delivering information relating to knowledge of food safety behaviours.

6.7 Answering Research Question Two

No significant differences were observed in any of the defined dependent variables for participants making up the *Text* and *Ctrl* experiment groups. The significant results that were observed involved participants making up the *VE* group. The significant improvements were seen in the consumption of two food items, consumed to assist with the prevention of stomach infections. Thus, to answer the second research question of whether VEs are better than more traditional media used for the delivering informational content (such as booklets), we found that VEs were shown to be more effective in these two (of three) dietary recommendations.

When looking at the comparison of effects between the three different experimental groups, it is important to look at possible differences between the participants and experiment groups.

Firstly, remember that after being assigned into their experiment group, *VE* participants were told that they would use a computer at their subsequent meeting. Two participants did not want to and were then randomly assigned to the other two experimental groups (see Section 5.1.1). Complete randomisation was not entirely appropriate. Therefore, the *VE* group may be seen as slightly bias in that they were comfortable in using a computer. However, participants were not chosen on the basis of their technical skill set, but rather on their comfort levels with the technology (after randomly being assigned to the group). This could have had an effect in the positive results observed within this group, but with the small sample size, it is not possible to explore this further.

The second difference between the participants was the venue at which they were recruited. Remember that two different government clinics in two suburbs in the Cape Town surrounding areas were visited. Due to the logistical requirements of this experimental study, all the VE participants were attendees of the first government clinic. This health care facility offered a regular support group, and all experiment meetings took place directly after their weekly meeting time. Unfortunately the second clinic did not offer a support group service to their clinic attendees, although attempts were being made to start one in the area. The experiment meetings at this second facility corresponded to the bimonthly dates that the HIV+ mothers collected formula food for their infant children. In addition to the therapeutic benefits of receiving regular support from a group of HIV+ women faced in similar situations to themselves, the *VE* participants likely had access to more information through this network of support. It is likely that the beneficial aspects of attending a support group at the first clinic affected the sample of participants that made up the VE experiment group. Considering however that the remaining two groups were recruited from both health care facilities, it is not clear what this effect would be.

Also, the fact that there was no significant difference between the experimental groups for *Food Safety* and the majority of variables making up *Dietary Quality* is a null result. However, it is still encouraging for new technologies such as VR which in effect have shown to be as effective as traditional media which has been used for a long time.

6.8 Experiences of VE Participants

We were interested in the effectiveness of a VR application for a target audience that had minimal prior computing experience. Although there was no research question covering these results, it was important to gauge the *VE* participants' subjective responses to experiencing such a new technological intervention.

From the interviews conducted immediately after experiencing the VE, three themes that arose from a content analysis of the transcripts. The first was the quality of information presented in the VE. A great deal of effort was placed into collecting reliable HIV-related information from numerous sources – the nutrition information was gathered from Internet sites of reputable HIV/Aids organisations, books, local government documents and international Aids organisations. The support group narratives were compiled by a clinical psychologist and HIV counsellor. A subset of this information was then packaging it into coherent groups and scenes, suitable for the house context. When writing the dialogue for the VE, effort was made to use vocabulary and diction aimed at Grade 10 reading level. We wanted the VE to be as accessible as possible, to the average South African and it is important to ensure the content is accessible to users who may not have completed secondary schooling, and also do have English as their primary language. Because the intervention was educational in nature, it was also important to include appropriate, clear explanations of recommendations, to assist with understanding of the message. The participants responded well to this by mentioning the usefulness of the information, and highlighted the need for such information.

The second theme that arose from the interviews was the ease of use of the system. Five out of the eight *VE* participants had in fact used a computer before, but as stated before in Section 6.7, this group of participants was biased in that individuals who were assigned to this group were comfortable with the notion of using a computer. Compare this ratio to the 3 out of 14 participants making up the two other groups who had used a computer prior to the experiment. Regardless, the participants found the system easy to use, and the time it took to train individuals to navigate the environment was minimal. This is very promising finding, as it suggests that the system would be adopted and utilized by users with minimal prior computing experience.

The final theme identified through analysis of the interviews, was accessibility of the information. Although there is plenty of HIV-related information available to the general public, it is generally not accessible to many South African individuals infected with HIV. Barriers to access include among others, computer literacy. It is important that both the information and the medium in which it is delivered, is accessible to the intended target audience.

There are other media which are more accessible (such as video or television programmes), which some participants stated, due to financial constraints and general lack of resources, are more accessible to the general public. The VE, as experienced by the participants, was a single user experience and that user wore headphones for the VE soundtrack. Because of this, some participants were reluctant to recommend it as a method for information delivery as compared to a video programme. However, this changed after introducing the idea of broadcasting the soundtrack on speakers and describing how multiple individuals could experience the VE simultaneously.

6.9 Chapter Summary

The primary aim of this research study was to investigate the effectiveness of VR as a communication medium and this was done in two ways: Firstly investigate the effectiveness of VR to delivery informational support to its VE users, and secondly, to compare the effectiveness of VR against paper-based medium for information delivery. In the previous chapter we presented all qualitative and quantitative results supporting this research, and used this chapter to discuss these findings in detail. VR was found to be more effective than the booklet for one particular area of information: Preventative measures are dietary recommendations that HIV+ individuals can do to reduce the risk of, and even prevent certain common ailments. Stomach infections are particularly problematic with HIV infection and eating three specific food items (carrots, garlic and pumpkin seeds) regularly can assist with the protection of the stomach. All participants that experienced the VE showed improvements in the consumption of two of these food items (carrots and garlic).

Chapter 7

Conclusions & Future Work

In the previous chapter, a discussion of the results obtained in the three experiment meetings conducted for this research, was presented. We now conclude this dissertation by revisiting the research aims underlying this study, and how these were addressed. We look at the experiment as a whole and describe the key challenges and considerations in conducting a field study with HIV+ women frequenting South African government clinics. Based on the observations made by the participants who had minimal prior exposure to computers, recommendations for VE design targeted at such non-computer literate individuals are then presented. We conclude this dissertation by giving directions for future work.

7.1 Addressing the Research Aims

The primary aim of this research was to investigate the feasibility of using VR as a communication medium to provide informational support to South African HIV+ women. This covered our scientific aims of investigating the effectiveness of content delivery, the impact of using computers, cost of providing it and the ethical considerations for the intervention. The secondary aim was to investigate whether VR technology was usable for individuals with little or no prior computing experience.

Due to its apparent high expense, VR is generally more commonly available in developed countries. We were thus interested in using a cheaper alternative to the expensive VR equipment by creating a desktop VE. One of the goals of this research was to create a locally relevant and applicable VE for South Africans.

HIV/Aids affects millions of people in our country, and we wanted the environment to provide a safe, familiar context in which supportive information related to HIV/Aids can be presented. We chose nutritional support as the specific type of informational support, as this is a highly relevant topic to people living with HIV. Improving the nutritional status of an infected individual can have a significant impact on HIV prognosis (see for example [98-100]). The system was designed to be easily expandable and modular.

Computer literacy rates in South African communities are extremely low and we were interested in researching whether VR technology is appropriate, effectiveness and usable for users with little or no prior computing experience. Although 8 (of 22) participants had used a computer before the time of the experiment, three of these described their computer experience as once-off participation in six week PC training courses. Of the 22 participants, 16 individuals had never heard about the Internet. Two participants had used it prior to the experiments, and only one individual had accessed HIV/Aids information through the

Internet (accessed by a colleague). Despite this minimal prior exposure to computers, every participant reported that the system was easy to use. Training time was minimal (five minutes), and this is evidence that VR is an appropriate and usable technology for our intended users.

To assess the effectiveness of the VE in delivering informational support to users, two different concepts were investigated: *Dietary Quality* and *Food Safety Knowledge*. Using a pre-post-test experimental design participants were randomly assigned into one of three experimental groups: one group experienced the information rich VE, one group received a paper booklet of the VE content, and the third acted as a control. Using this experiment design we were able to compare the VR medium to the more conventional medium used to deliver HIV-related information to the majority of HIV+ South Africans who visit government clinics (i.e. paper booklets).

The instrument used to measure changes in participants' knowledge of food safety practises was problematic in terms of both language barriers and cultural differences. It was designed using population samples from the United States of America [80] and was found to be unsuitable for the participants involved in this research (see Section 5.3). For a subset of the *Dietary Quality* information, VE participants were the only individuals that showed a positive improvement. This information involved two (of three) dietary behaviours aimed at preventing stomach illnesses (a common problem for people infected with HIV). For these behaviours, VR was found to be an effective communication medium.

7.2 Conducting a Field Study with HIV+ Women in South Africa

Although small, the sample population used for this research study was unique in that is represented the population at which this intervention is targeted. That is, women who were recently diagnosed with HIV, and had recently, or were planning on having a child around the time of the experiments. Another important fact that highlights the uniqueness of the sample is that the experiment meetings took place at health care facilities at which the participants were active attendees. The study has very strong external reliability – it is representative of the real target users of such a system in the appropriate context. In a study that has high external reliability, the internal reliability generally decreases as it is not possible to control for all extraneous variables in the field.

The logistics underlying the implementation of the experiments described in this dissertation were substantial. With an understanding of the stigma surrounding HIV infection in South Africa, it is difficult to recruit HIV+ individuals for such a university research study. But by using existing structures within the public health care sector, an accessible population sample was formed. This was particularly important since we required participants to attend three different meetings over a five week period. Obviously, it was important to retain as many participants as possible for the duration of the study. By conducting the meetings immediately after a support group or a scheduled clinic visit, the return rate was optimised.

Due to the challenges identified above, the sample size for this research was low. In order to gain more of an understanding of these results, it would be very useful to repeat the study with a larger sample size.

7.3 Cost Implications for VR Applications in South Africa

In addressing the primary research aim of investigation of VR as a communication medium for the provision of informational support to South African HIV+ women, it is important to

consider the cost implications of creating and deploying such a system. The costs that need to be identified are categorised into hardware and software.

In this research, the VE was deployed on a standalone desktop personal computer and standard, inexpensive peripherals were used for input and output of the system. The equipment required for desktop VR is both affordable and attainable in South Africa. It should be noted however, that in South Africa, there is a high levels of crime. For this research study, it was not possible to leave the hardware at the facility for extended periods of time. The experimenter physically transported the necessary hardware to the health care facility for the required meetings.

Designing and implementing a VE such as this requires the expertise of a number of specialists. These range from 3D modellers to HIV/Aids content specialists and these are the largest cost consideration when implementing such a VR system. In Section 3.7.2 different animation techniques were used for the virtual characters, and the use of shorter, re-usable animation sequences were preferable and more cost effective. It is not within the scope of this dissertation to do a full cost analysis. However, in comparison to first world countries, the human resource costs in South Africa are considerably lower. This also suggests that a VR system such as the one described in this dissertation is affordable within the South African context.

7.4 VE Design Recommendations

A distinct advantage of VR as compared to other media, is that of interactivity. That is, typically a VE user is able to choose the content they want to experience, and the order in which that content is delivered. The VE used for this research study allowed for, and encouraged this type of interactivity. In the kitchen, the user could choose from a number of different areas of nutrition support, either by navigating towards an area or selecting content using a crosshair. These actions within the VE triggered the information delivery.

To assist with navigation, a guiding agent was also used to guide, introduce and present the informational content. When the user entered the kitchen, they were greeted by *Sandi*, the guiding agent for the scene. After initial introductions, she told the user that there were two areas of interest in the room. She described the food group area first, and followed this by an introduction to the cleanliness and hygiene area. Without exception, all users first explored the food group area, and ended their VR experience in the cleanliness and hygiene area of the room. Although a choice was available, all users followed the same order of events within the room, suggested by the guiding virtual agent.

The significant results in this research were observed in two (of three) dietary behaviours aimed at the prevention of stomach complaints for HIV+ individuals (see Section 5.2.5). The area that contained these recommendations was positioned in the *Cleanliness & Hygiene* area in the VE, and due to the guiding virtual agent in the kitchen, was the last area of knowledge experienced in the VE by all participants. Because of this, it is likely that they were more easily remembered than the other content. As mentioned in Section 6.2.4, this is known as a *recency effect* and is often coupled with a *primary effect*: If one is given a list of items to remember, one is more likely to remember the first and last entries, than the ones placed in the middle of the list. In this work, the primary effect was seen in the virtual support group as this was the first scene that users experienced in the VE. Three out of the eight subjects specifically mentioned their interest in this particular scene and rated it as one of the most important. This effect has repercussions in VE design, in that the placement of the more important content should be positioned towards the start and end of a VE, and by using a guiding agent, users can be encouraged to follow this recommended navigation order.

It is also important to note that within the area that improvements were seen (*Clean Stomach*), only three behavioural changes were recommended. In Section 6.2.4 we suggested that one of the reasons for the observed improvements was this minimal number of changes. When designing a VE, the most important information should be identified, grouped and presented together. There were three items in this category (*Clean Stomach*) – we would suggest a maximum of seven.

As presented in Section 5.2.1, more than half of all participants reported that they ran out of money for food. This is an important consideration when designing a VE and deciding the content for the environment. The participants for this research are representative of the target users for this intervention, and this lack of financial resources is a common problem for many people living with HIV/Aids in South Africa. Always recommend the most inexpensive items within the intervention.

The above guidelines are summarised in Table 7-1 below.

Table 7-1: VE design guidelines based on results observed within the VE participants

Guideline	Description
1	Encourage interactivity from the user
2	Use a guiding avatar to ensure user is made aware of all content
3	Use a guiding avatar to encourage a specific route through the VE
4	Identify most important key information (maximum seven items) and present these at beginning or end of specified route
5	Focus on most inexpensive items and recommendations when deciding the VE content

7.5 Additional Observations

The research questions focused on two core measurements that could be used to compare the effectiveness of VR as a communication medium. Additional benefits however were highlighted by those individuals that experienced the VE.

7.5.1 Empowerment

A theme not anticipated was the psychological impact of the medium itself on the participants. Participants felt privileged at being given the opportunity to use a VR application. It instilled in them a sense of power and achievement. The ongoing socio-economic disparity in South Africa has resulted in limited access to technological innovations such as computers and the Internet for many. Computers are associated with a chance for better opportunities. One participant in particular expressed some disappointment at the final meeting with the experimenter since she had incorrectly assumed that she would be able to experience the VE again.

> *"I like the computer, ja. I like the information"*

One participant learnt an important lesson in the VE regarding protein sources. This knowledge is likely to assist her financially, and may result in dietary change. However this change would not be seen using the measurement techniques used in this study. Conducting a thorough dietary assessment experiment is a difficult endeavour, as there are numerous different measurement techniques. Many of these require the expertise of a dedicated dietician (not available for this study). Additionally, the types of variables that are measured in dietary assessment experiments vary greatly. A change indicative of this is described below by the participant. It would not have been observed in the statistical analyses of the

data from the food diaries. It does however highlight a desirable result of such an intervention.

> *"Thank you for all this because I was not having enough information about my nutrition as a positive person. And I was always looking for expensive food not knowing that instead of meat I can just take beans, which I can plough in my garden."*

The majority of the participants had minimal prior computing experience, with some never having touched a computer prior to the VR experience. They met this challenge with varying degrees of excitement and trepidation, but generally felt strengthened and empowered:

> *"For me I like a computer. I like a computer – I don't want to lie. For me. Because in the computer ah, I do all these, ah, I drive this cat* [the mouse] *by myself, you see? Like, it's a, some sort of, a training because I've never used a computer – so, so interesting that um, I'm trying to get all this, all you talking about. So, have to use my mind and focus on what I'm doing while on a TV I'm just going to sit down and watch. Sometimes I focus 'What did he say?' You see?"*

> *"Yoooh it was very .... First it was a great opportunity because it's my first time (using a computer) and it is interesting. I wish I can do more, so that I can learn more ... so interesting."*

The VE participants were excited about their achievements within the environment with one subject congratulatory clapping the first time she correctly selected an object within the VE. A system that both educates and instills a sense of empowerment is desirable.

7.5.2 Stigma and Discrimination Issues

Negative stigma and discrimination surrounding HIV infection is common in South Africa (see Section 2.1.3). In this study, this was illustrated by the difficulty we faced in getting actors to be photographed as models for all the virtual agents. We found that many individuals were not comfortable being represented as HIV+ people in the VE. Because of this, the kitchen agent (*Sandi*) was based on artistic sketches, rather than photographs of real people (such as those used for the three characters in the lounge).

The VE was designed to be a warm, relaxing and inviting environment, in which users could feel safe. Effort was made during the design to use familiar contexts, and this was achieved through the number of field trips to get photographic material of homes in a low-income suburb in Cape Town. This intention was interpreted by one participant:

> *"Everyone was friendly. It's a kind of home feeling – it gives you a home feeling."*

In the first study of this research program, a virtual support group was designed in which HIV+ users could access personal narratives of coping strategies with HIV infection [57]. We found that a virtual support group can provide additional benefits to the HIV+ user in South Africa. Primarily, users can meet (virtual) people who are open about their HIV status. The participants that viewed the VE in this study were able to identify with the virtual agents in a world where people accept their status, and are openly living as a person infected with HIV.

> *"I would choose to be Andile because Andile is got everything that means, in his life. Like the house, the life, the life that is Andile living ... he is living positively. He don't hide HIV. His HIVs. He don't drag, take the HIV under the blanket. He just talking about HIV. He's not scared anymore about his HIV. As a result, he is living positive."*

"something I did like is that they're open about their status. And they are having some sort of a support group there where they empower the others and they share their feelings with the others so that, even if, you are not their colleagues, they're still afraid they must know what to do and not to"

The issues surrounding HIV-related stigma and discrimination in South Africa are large and complex and it is important that a therapeutic intervention such as the one used in the research study takes this context into consideration. The VE did provide a non-judgemental environment in which virtual characters were depicted as living positively with HIV.

7.5.3 Attribution Effect

Attribution theory is concerned with the perceived causation of behaviours [101]. Basically, a person interprets behaviours in terms of its causes, and this perceived causation plays an significant role in the person's reactions to the behaviour [101]. In this study, two participants interpreted the animations, dialogues and appearance of the virtual agents, in ways not expected nor intended, by the VE authors. In the quote below, one participant described *Pieter*, one of the agents in the lounge:

"like that white man, because I think, what I'm saying is that he's in denial because when he greets me he's just say "HI - WELCOME", nothing else but the others just talk to me, and explained what, they are HIV positive. They are like me. So I think he's still in denial. And, I heard him asking that lady that how did she cope about the status. I think he's still not ready. Ja."

The narrative in the lounge was meant to serve as an introduction to the environment, and three agents were used to create a welcoming support group. The resting pose for the actor described by the participant, was a stretched-out pose and his animations did unintentionally appear forced. Additionally, his narrative was significantly shorter than the other two actors in the group (*Andile* and *Joey*). It was not the intent of the animator, nor the script writer, but an interesting observation.

Additionally, one participant gives an interesting comment regarding the physical appearance of the virtual agents. For rendering and speed purposes, the modeled agents had a low polygon count. One participant interpreted this as follows:

"Ja if I saw this before, when I was still in my denial, then I would be very scared. The people there have the small shoulders, and I was thinking that I will be like that, the HIV."

It is important to note here that there are different expectations from the VR medium for different individuals. This is particularly true for individuals who are not familiar with the technology. It is simple to overlook certain things because one is used to the medium, or understands its capabilities and weaknesses. A different message can be conveyed to the novice end-user, as described in the above two comments from participants, and care should be taken in this regard.

7.5.4 Participants' Motivation

Many participants expressed a definite eagerness to be involved in the research study. Some of these deserve mention: One participant captured her dietary intake on the day that she gave birth to her child. Both food consumed before and after the event were recorded. It is very impressive that the participant remembered to complete the diary on such a day. Another individual was unfortunately robbed of her personal belongings on the way home from the first meeting. Because her stolen bag included the food diary from the first meeting,

this participant wrote down her dietary intake on a separate piece of paper, which she brought to the second meeting. This type of willingness and eagerness to partake in the study was due in part, to a lack of basic information available to many participants. The 28 page booklet provided a useful information source for many participants:

> *"I read the book thing everyday to check the nutrition information .... like the cups and bowls. My sister also reads it often and found it useful"*

This does provide evidence that there was a desperate need for HIV/Aids related information, and that the individuals involved in this study did not have access to such comprehensive information.

7.6 Future Work

In the course of conducting this research, six possible directions for future work were identified. Initial work has commenced in some of these areas, but was not included in the VE used in this research study.

7.6.1 Translation of Experiment Documents

It was clear that language played an important challenge in the administering and use of the Food Safety Knowledge Questionnaire (based on [80]). At the end of the experimental meetings, the experimenter gave each participant the answers to the knowledge questionnaire, and described each item within the instrument if requested. During the post-experiment discussions, one participant responded to some of the questions stating that she misunderstood them, and if better descriptions were available, she would have answered the questionnaire item differently.

If this research were to continue, it would be of utmost importance to translate all the experimental documents (from the information sheets, consent forms and interviews) into both isiXhosa (the primary language of all but one participant of this study), as well as Afrikaans. Both languages are required if this work were to be investigated further, within the Western Cape province of South Africa.

7.6.2 VE Soundtrack in Multiple Languages

South Africa has eleven official languages and most pamphlets from the Department of Health and other government departments are usually made available in a small subset of these languages (the choice of languages depends on the province). If VR is to become an accessible communication medium, it is important that research is focused on the benefits of having multiple soundtracks available to users. Although the advantages and disadvantages of experiencing a VE in a user's home language were not clearly available in this research, it was made apparent that it would have been required for one particular individual (from the *Ctrl* group): When this participant received their textual pamphlet of the informational content, she returned it immediately stating that it would not be of benefit to her. She stated that she struggled to read English since it was not her first language. She would require assistance, and since she had not disclosed her HIV status to her family or friends, she was unable to get benefit from an English pamphlet.

The narratives created for this research have been translated into both Afrikaans and isiXhosa, the two most commonly spoken languages in the Western Cape province. Future

experiments should be conducted on a larger scale to assess the benefits of the availability of multiple languages.

7.6.3 Continual Usage of System

The *VE* participants only experienced the VR once-off, at their second experiment meeting. It would be interesting to make the application accessible to all participants and monitor its usage over an extended time period. This way the experimenters could get an accurate indication of the users' involvement in, and usage of, the system. This is the common procedure for similar systems, such as CHESS (described in Section 2.3.2), which was installed in individuals' homes (usually between three and six months).

There are reasons why such a physical setup of computers was not viable for this study. Firstly, it is expensive to provide a computer to over 30 individuals, both in terms of equipment and technical support. South Africa has a very high theft rate, and internet connectivity (for remote monitoring of usage) is virtually non-existent in low-income communities. It was thus not viable to install computers in participants' homes. The solution used in this research was to take equipment to a central location (government clinic) which could be easily accessed by experimental participants. A one month interval was chosen as the time period between experiencing the intervention and a follow-up meeting where behaviour and knowledge change could be assessed. To investigate whether such a VR application would be used and adopted by government clinic attendees, it would be interesting to leave the computer at the clinic for an extended time period, and monitor usage. This could be in terms of repeated usage, as well as new users.

7.6.4 Additional Content

All participants that experienced the VE stated that they would revisit the virtual house if more information was made available within the environment. Additionally, all users experienced every area of the VE, and many actually seemed surprised at the end of their VR experience, that there was no additional information. There is a wealth of information and advice available that could be of benefit to people infected and affected with HIV. Comments from the semi-structured interviews indicate a definite need for the development and inclusion of additional content.

The setting of the VE was a house, with rooms containing related aspects of living with HIV and Aids. It is an expandable design in that additional rooms can be used for further enhancements and content. Possible extensions to this environment would be the provision of educational content on sex issues (presented in the bedroom), and issues relating to mother-to-child transmission (MTCT) in a baby room. In Figure A2-2, the floor plan shows two existing rooms (bedroom and bathroom) that can be used for additional content.

Although we had thought that the amount of nutrition information in the VE was comprehensive, two participants suggested additional content for this room.

> *"Because sometimes we are dealing with a people who are HIV positive, others they are HIV positive and diabetic, others they are having TB. So sometimes there's a conflict with the nutrition to people who are HIV positive, or to the people who are diabetic. But she did try to explain everything. But I want to know more about the different ... the nutrition for the diabetic person and HIV person and TB patient, you see."*

> *"I would have liked, um, but I don't know if that would have helped. I would have like it if she had to, sort of like, um, she had shown us all of the different groups in that section. I would have liked, if maybe if they would have to, perhaps to prepare something and then cook*

something. Ja, sort of prepare something with all the things that she's shown you or anything like that"

Note that at the time of the VE design, the anti-retroviral therapy program was not widely available through government health care facilities. Since then however, South Africa now has the largest ARV program in the world. Additional content has already been developed for this VE that includes such information. This room, named the *Treatment Room* contained one virtual agent (named *Nobuntu*) who provides information on two treatment programs: antiretroviral therapy (ARV) and mother-to-child transmission (MTCT). In Figure 7-1 below, Nobuntu is explaining how to take the ARV medication. As future work, experiments should be conducted examining the benefits of including this information in the VE.

Figure 7-1: A *Treatment Room* has been developed in which antiretroviral therapy (ART) and mother-to-child transmission (MTCT) programs are discussed.

7.6.5 Robustness of Software

A possible implementation of such a VR system would be in South African government clinics. If this were to be realized, a great deal of attention would need to be placed on ensuring the system is robust, and thorough system testing would need to be conducted. If a user were to cause the system to crash for example, any confidence that person may have gained in using the system may be in jeopardy. Also, in light of the limited staff available at government clinics and the overstretched public healthcare in general, it is important that a computer-based application does not rely on their expertise, time or energy to keep it operational.

7.6.6 Collaborative Virtual Environments

At the end of the experiments, participants that had experienced the VE were asked if they would enjoy meeting in a collaborative VE (CVE). While it was difficult to describe this specific type of technology to our users (due to their lack of knowledge of such a system), the authors do believe that such a collaborative environment could greatly foster learning and aide more with the challenges of stigma and disclosure surrounding HIV infection. The cost of transport (especially for unemployed individuals) is a major barrier is accessing health care in South Africa [102]. One benefit of a CVE is the ability to connect individuals in geographically different locations.

7.7 Final Comments

Considering the small sample size, the fact that the participants who viewed the VE showed a positive improvement in the consumption of two of the three food items making up the preventative dietary behaviours, is impressive. The fact that these recommendations were isolated within the environment, and that they were the last area experienced within the VE is significant. It shows that VR can indeed be used to deliver informational content to women infected with HIV in South Africa. However, the fact that this was the only area that showed improvement highlights how careful VE authors should be in choosing both the actual content for the environment, as well as how that content is delivered. In the VE used for this research study, there was a central guiding avatar in each of the rooms of the virtual house. This character ensured that the user was made aware of every area of information within the environment but also indirectly resulted in all users experiencing the content in a similar order. One of the distinguishing characteristics of VR is the non-linearity of the storyline or plot, but our novice users followed the order that the guiding avatar recommended. Such guidance should be considered during the VE design and creation. Understanding the recency effect as shown in the results of this study, can also be used in designing interventions using other communication media. If we look at delivering content via video for example, emphasis could be placed on the information presented at both the beginning and end of the video programme.

Designing and implementing a sensory rich VE is a time consuming endeavour. It requires the expertises of animators, models, artists, photographers, content authors, voice actors and software developers. The benefits of creating such an application must outweigh these costs, and the significant results observed with participants who viewed this VE justify this. Prior to the intervention, these participants were not consuming specific food items; items recommended specifically for HIV+ individuals to assist with the prevention of stomach-borne illnesses. One month after viewing the VE, these individuals were.

We are greatly encouraged by the results of this study. We feel that while the VE requires expansion in terms of the amount the information presented, VR is an extremely useful and promising medium for our target population. Off-the-shelf hardware, which is affordable to both government agencies and NGOs, was used. Therefore the deployment of such a VE system in a number of clinics or mobile clinics is economically viable. Also, our interviews indicate that patients want and are able to make use of the system. So it is unlikely that the systems once deployed will lie idle. Also, due to the simplicity of the system, peers could train each other in its use, even in communities with low literacy and computer literacy rates. Although computing experience was minimal, all participants mentioned that they found the system easy to use and enjoyed their VR experience. Additionally, training time was minimal (five minutes). This provides some evidence that VR can, and would be used in communities with low levels of computer literacy.

The outstanding feature of this system is its potential to empower communities to deal with the HIV epidemic. The current shortage of medical staff and knowledge pose a problem since many people have little means for coping with the disease. However, by making high-quality information easily and widely available, the emphasis can shift from looking to a scarce group of outsiders to provide solutions, towards looking to one's peers to cope with the problems of living with HIV. Patients can not only exchange information, but, by teaching each other how to use the system, increase the flow of information from the medical community to the patient community.

Appendix A

VE Design Documents

Appendix A1: Storyboard

The document presented below was created in Microsoft Powerpoint, and was used to describe the physical layout of the environment as well as descriptions of furniture that required modelling. This document served as a communication medium for modellers and reference material (predominantly photographs taken during field trips) was used throughout.

Floor Plan of House

Outside View of House

The picture here shows a front view of the house. There are actually two houses in this picture (joined), but only model the house on the right. The user will start the VE outside the front gate.

Front Garden

These are views of the front garden. There should be a walkway leading from the gate to the front door. You can use bricks (as shown in pictures above) to create the path way. Don't include the metal barrier that is shown in the picture (to the left of the front door). Green bushes and colourful flowers should be placed underneath the two windows. A green tree should also be placed in the garden. The lawn should be healthy and green.

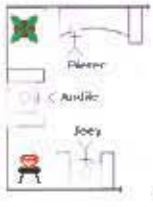
Front Door & Front Gate

Here we have the front door of the house, and the front gate. Both of these should be modelled according to the reference pictures above. And both should be able to open and close.

The Road

These are views of the road. Street lamps should be modelled and placed along the road side. We will use a skybox to create the illusion of other houses along the street.

The Lounge



The diagram on left shows the object placements in the lounge. One 2-seaters and two 3-seater couches are required. A potplant needs to be placed in one corner (there is one in the picture below), and a fruit bowl (with apples, oranges and mangoes) in the other. There is a window above the 1 seater that looks out into the front garden. It has opened curtains (reference pictures to follow)

This lounge suite here, should be used as a basis during modelling

The Lounge (2)

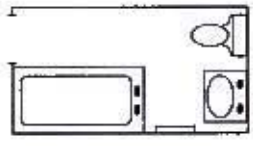
More reference pictures of the lounge suite. Do **not** model a coffee table (not required).

The Lounge (walls, floor & curtains)

The walls of the lounge should be white, and the floor should be textured with any texture similar to the one shown here. A carpet will be placed in the middle of the lounge (circular).

The Bathroom

The diagram here shows object placement in the bathroom. This room will have a sink, toilet and bath. There is a towel rack on one wall, which has one blue towel placed over it. There is no need to include a mirror in this room since the VE will be experienced from a 1st person perspective, and don't require the user to see a representation of themselves.

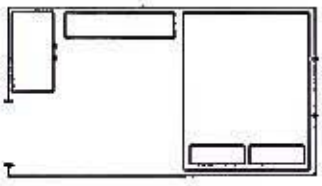


The Bathroom (2)

The floor should be textured using a similar one to that seen in the pictures above ('floor paper'). The walls should be white. There should be a larger gap between the sink and toilet (the toilet can be placed right next to the side wall). I also need a bath mat and mat for the base of the toilet.

The Bedroom

The bedroom will contain a double bed, a full-length cupboard (in top left corner of diagram below) and a chest of drawers. There is also one window in this room, decorated with a colourful, opened curtain. The bed is neatly made, with a duvet cover and pillow. The walls of the bedroom are white, and the floor should be textured with a cream carpet.



The Bedroom (2)

For the full-length cupboard, the 'Closet' that has already been modelled can be used. It does however, need to be re-textured to make it look old and wooden.

The wooden chest of drawers should be modelled according to the reference picture.

Bedroom Curtains & Linen

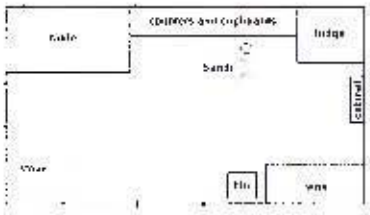
The railing that holds the curtain should look like that shown here. The actual material of the curtain can be the one you've used in the past

The duvet cover and pillow should be textured according to the reference picture shown here.

Picture of duvet cover and pillows to follow

The Kitchen

The diagram here shows object placement within the kitchen. There is a window (between the stove and table) that looks out into the garden. Curtains need to be placed here. The walls of the kitchen should be white.



The wooden table in the kitchen

The carved wooden table that has already been modelled can be used. But we need to modify it to suit the setting.

- Although the reference picture (& the previously modelled one) shows a low table, I need it to be waist height
- The table top needs to be re-textured to look like the picture shown here. The carved table top already modelled, looks to fancy and expensive for the setting.
- The table should be rectangular in shape (not square as is shown in the reference pictures here)

Counters & cupboards in the kitchen

The reference pictures above show the types of cupboard and counters required. The counters need to be placed along the wall between the wooden table and the fridge, so can't need any corner counters. Cupboards both underneath and above the counters (as shown in the picture above right) are required. The 'Cabinet' & 'Drawers' (in the kitchen list) that have already been modelled can be used for the bottom cupboards and counter, but need to be retextured to look more like that shown here. As usual, the models look too expensive for the setting. The top cupboards should be modelled according to the reference picture above right.

The fridge in the kitchen

The fridge that has already been created can be used But it should be retextured since silver fridges are very expensive. It should be white, and similar to the fridge shown here in the reference picture.

The sink in the kitchen

The 'Basin' (from the bathroom list that has already been modeled) can be used for the sink in the kitchen. However, the cupboard below it should be retextured to look more like that shown in the picture here. The previously modelled basin looks too expensive for the setting. There is no need to include the cupboard above the sink (as shown in the picture here). Do not model the white plastic drying rack.

Appendix A2: Event Flow Document

The Event Flow document was used during the scripting stage of the VE creation. To deal with the non-linearity of VR, related interactions were grouped together. Since a house was used as the setting, each room provided an easy separation for these interactions. The interactions between the user and characters in each of the rooms were grouped together, and called a scene. Offline HTML pages were used to manage the scripts and possible event flow between the different areas in the VE. A scene within the VE had a corresponding HTML page. In the same manner that a VE user can walk into a different room and hence experience a different scene, hyperlinks provided an easy way to navigate within the document structure.

overview of entire environment	scene 1 arriving at the house	scene 2 virtual support group	scene 3 the kitchen *diet analysis (wooden table)* sugars cleanliness and hygiene (sink)

Scene 3A: Sugars Group

As Sandi unpacks the items from the "Sugars" bowl into the centre of the table, she gives their names:

Sandi: In the sugars group, we have some chocolate, sweets, biscuits, a fizzy drink and obviously, some sugar.

[Sandi finishes unpacking the items.]

Sandi then goes on to explain the basics of this group of food items:

[Sandi points at the bag of sugar on the wooden table.]

Sandi: Sugar is not very good for us. It feeds thrush which is a common infection for HIV+ people. You should reduce the amount of sugar in your diet as much as possible, including the sugar in your tea and coffee. A lot of sugar can reduce the number of fighter cells in your body which can cause lots of different health problems. If you have an infection, don't have any sugar. But if you are healthy you can have a small amount.

[Sandi points at the chocolate, biscuits, fizzy drink and sweets on the wooden table.]

Sandi: These other foods here aren't very good for us, because they have a lot of sugar in them. If you're really craving them, you might not be eating enough energy foods.

overview of entire environment	scene 1 arriving at the house	scene 2 virtual support group	scene 3 the kitchen *diet analysis (wooden table)* fats & oils cleanliness and hygiene (sink)

Scene 3A: Fats & Oils Group

As Sandi unpacks the items from the "Fats and Oils" bowl into the centre of the table, she gives their names:

Sandi: In the fats and oils group, we have some butter, a bottle of plant oil, and some takeaway food.

[Sandi finishes unpacking the items.]

Sandi then goes on to explain the basics of this group of food items:

[Sandi points at the take-away food on the wooden table.]

Sandi: Our stomachs' struggle when we eat fried or greasy foods. They sometimes cause diarrhoea and stomach upsets.

[Sandi points at the bottle of oil on the wooden table.]

Sandi: A little bit of oil with your food is okay, but not too much. You should choose uncooked plant or fish oils, and not cooked oils from milk products or meat.

[Sandi points at the block of butter on the wooden table.]

Sandi: A little bit of butter is also okay in your diet, and butter is better than margarine.

Scene 3A: Vitamins Group

As Sandi unpacks the items from the "Vitamins" bowl into the centre of the table, she gives their names:

Sandi: In the vitamins bowl, I have 6 different ones that are important for us. I've got Selenium, zinc and vitamins B, A, C and E.

[Sandi finishes unpacking the items.]

Sandi then moves through each of the vitamin bottles, explaining the basics of it.

[Sandi points at the Selenium vitamin bottle.]

Sandi: If you have HIV, Selenium is the most important and the most powerful vitamin. People with HIV really need to try their best to take this vitamin every single day. The cheapest way of getting it is to buy selenium pills but if you can't, then you can eat a cup of Pronutro or sunflower seeds. Or, having 1 brazil nut will give you enough selenium.

[Sandi points at the Zinc vitamin bottle.]

Sandi: Zinc helps your immune system work properly. You can get it from foods that are rich in proteins, but it's difficult to get enough from your food. You should rather buy zinc tablets. They're not very expensive.

[Sandi points at the Vitamin A bottle.]

Sandi: The cheapest and safest way of getting vitamin A, is by eating 3 to 4 raw carrots every single day.

[Sandi points at the Vitamin C bottle.]

Sandi: Vitamin C is found in lots of fruits, especially citrus fruits, mangos, paw-paws, guavas and tomatoes. But because the amount we need is so high, it's best to buy it from the pharmacy. The cheapest form of vitamin C is ascorbic acid, which you dilute in water.

[Sandi points at the Vitamin B bottle.]

Sandi: There are lots of different types of vitamin B. The ones we need are B12, B2, B6 and Folic Acid. They slow down the virus. You can get these vitamins from eating sardines, oysters, tuna and other dairy foods. Or you can buy general vitamin B tablets from the pharmacy.

[Sandi points at the Vitamin E bottle.]

Sandi: It's good to take vitamin E with your Selenium. This vitamin helps your immune system work properly, and can also slow down the virus.

overview of entire environment	scene 1 arriving at the house	scene 2 virtual support group	scene 3 the kitchen diet analysis (wooden table) cleanliness and hygiene (sink)

Scene 3B: Cleanliness and Hygiene

The user has walked over to the sink area, and pressed the select button. Sandi follows the user to this area in the kitchen. While she is walking, Sandi gives an introduction to this area of interest:

Sandi: You've chosen to learn about cleanliness and hygiene.

[Sandi arrives at the table and turns to face the user.]

Sandi: Germs can live in food and can cause anyone to get sick. We must be safe with food because we are trying to keep ourselves, our bodies and the food we eat, germ-free.

Three icons are placed on the wall above the draining board. These relate directly to 3 different areas of interest in "Cleanliness and Hygiene". The user is then able to choose which area they'd like to know about. They are:

- Clean food (this icon is a selection of different food items)
- Clean water (this icon is a tap)
- Clean stomach (this icon is a person with the stomach area highlighted in blue)

Sandi: As you can see above the draining board, there are 3 things here. They are: "Clean Food", "Clean Water" and "Clean Stomach".

[Sandi points to each of the 3 icons as she mentions them.]

Sandi: All of these are very important to know about if you or someone in your family has HIV. If you choose one of them, I will tell you more about it.

[Sandi pauses for a moment, waiting for the user to make a choice. If the user has not chosen anything in 4 seconds, Sandi asks the user again to make a choice:]

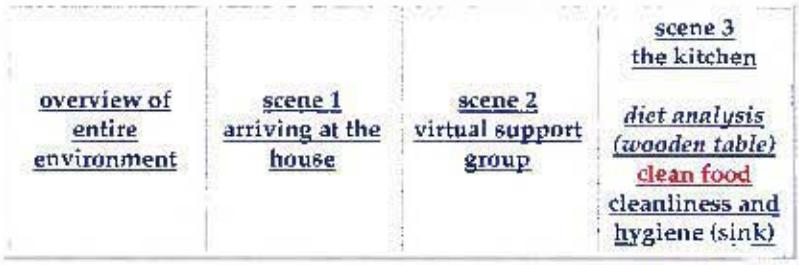
Sandi: Go ahead, choose one of the three.

- Clean Food
- Clean Water
- Clean Stomach

Sandi waits for the user to make a decision. The user is able to select an icon by pressing the select button when it is in their view. When a choice is made, the respective icon gets a blue background, identifying it as the current selection. Sandi then gives details of that particular icon. When she has finished giving all the relevant information on that icon, she asks the user if they would like to know about any of the other areas. The blue background then disappears.

Sandi: That's all I can tell you about this area. You can choose another one if you want, or we can go to the table over there.

Each of the 3 areas has a number of points that need to be conveyed to the user. Sandi explains some of the points, using animations and dialogue. Numerous objects will be used as Sandi does the demonstrations. These are all initially placed in a basket next to the sink area. For each animation sequence, Sandi takes the required item from the basket, uses it, and then returns it to the basket.



Scene 3B: Clean Food

Sandi is facing the user. She turns toward the sink area, and turns on the tap with her right hand. She uses soap positioned above the sink to wash her hands, while she is telling the user about it:

Sandi: You should always wash your hands before you start making your meals, before you eat, and after going to the toilet.

Sandi lists some food items using a counting gesture, and shakes her head explaining the best way of cooking them:

Sandi: You should cook meat, fish and eggs very well. Cook it until there is no pink or red inside, especially chicken, bacon and other pig meat. Your eggs shouldn't be runny.

Sandi turns to the basket and picks up a tomato. She moves to the sink and turns on the tap. She rinses the vegetable under the running water. After 3 seconds, she turns off the tap and returns the tomato to the basket.

Sandi: You should wash all food very well before you cook it. If your water isn't safe, you can add 1 cap of bleach to a basin of water and wash your fruit, vegetables, meats and eggs in that water. The bleach will evaporate so you won't taste it.

Sandi turns to the sink and points at the tap. She returns to face the user.

Sandi: Water from the South African municipality is safe, but water from boreholes, rivers or dams needs to be cleaned.

Sandi turns to the fridge and points at the bottom freezer section. She shakes her head explaining about meat juices:

Sandi: Bloody juices from raw meat should be cleaned up as soon as possible. And make sure these juices don't mix with any other food.

Sandi turns to the basket and picks up a box of 6 eggs. She points at the expiry date, then returns the food item to the basket.

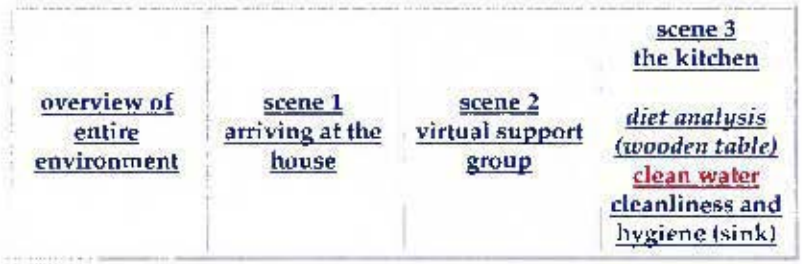
Sandi: When you buy food at the shop, always check the "best before" date. If the date has passed, you need to throw it out.

Sandi shakes her head, then gestures putting a lid onto a container, as she explains the correct way of handling the freezing of food:

Sandi: You shouldn't defrost food at room temperature. Rather put the frozen food in the fridge, in a covered container. Once your food is defrosted, you should never freeze it again.

Sandi turns to the basket and picks up a bottle of bleach and shows it to the user. She then returns the bottle to the basket.

Sandi: You should keep all the surfaces in your kitchen, all your utensils, and all your bowls and plates, clean and sterile. A cheap way of doing this, is to add 1 tablespoon of bleach to 5 litres of water, and use this solution to clean.



Scene 3B: Clean Water

Sandi is facing the user. She turns toward the sink area, and takes a plastic cup from the basket. She turns on the tap and fills the cup. She then puts the cup down on the other side of the sink.

Sandi: It's important that your body gets enough liquid, and water is the best for you. We need to drink 2 litres or 8 cups of clean, safe water every day. In South Africa, the water from our municipalities is safe.

Sandi faces the user. She gestures towards the tap with her arm, then gestures towards the fridge.

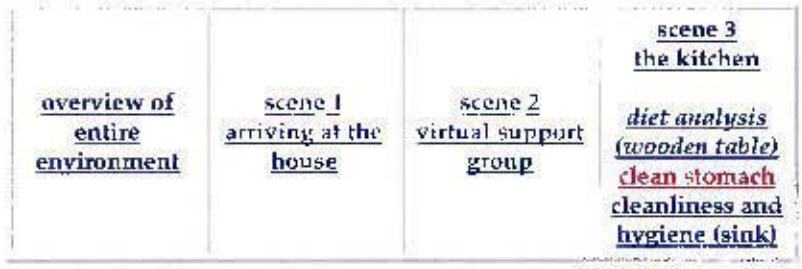
Sandi: But if your water comes from a borehole, river, lake or a well, then you first need to boil it to get rid of any germs or little insects. Then you can put the boiled water in the fridge to cool it down.

Sandi turns to the basket and picks up a bottle of alcohol and shows it to the user. After explaining its relevance to a person living with HIV, she returns the bottle to the basket.

Sandi: It is not a good idea to drink alcohol if you have HIV. It isn't good for your liver, and can make your body lose extra vitamins. Alcohol is really bad if you are on medication and might cause the medicine to not work properly. Drinking alcohol often weakens your immune system, which we don't want. Also, if you've had a couple of drinks, it might make it more difficult to practise safe sex which we all have to do.

Sandi faces the user. She gestures to herself, and makes gestures to represent a small amount. She shakes her head explaining the negative ingredients of beer:

Sandi: Alcohol absorbs water from your body, and we don't want to lose any extra water if we can help it. Having small amounts, like 1 or 2 glasses of wine in a week should be okay, but nothing more than that. Beer (including home made beer) has yeast and sugar in it. Both of these are not good for people who have HIV.



Scene 3B: Clean Stomach

Sandi turns to face the user. She gestures 3 fingers, explaining the different food items that are important to assist with the cleansing of the stomach.

Sandi: We want to keep our stomachs as clean as possible. There are 3 different things you should eat often to help with this.

Sandi turns to the basket, and picks up a pumpkin, and points towards the seeds in the middle of the vegetable. Upon finishing explaining the importance of this item, she returns it to the basket.

Sandi: Pumpkin seeds are very good for you. So when you buy this vegetable from a shop, you mustn't throw away the seeds. Rather dry them out in a warm place and then eat them. These seeds are very good for removing bugs and worms from your stomach, so they help to clean your stomach. Once a week, you should eat a handful of the seeds.

Sandi turns to the basket, and picks up a single carrot. She turns to face the user, and points to the carrot while she explains the importance of this vegetable. Upon finishing the explanations, she returns it to the basket.

Sandi: Carrots are also very good for you. They give you vitamin A, and are also very good for dealing with worms and other stomach bugs. At the very least, you should have 4 carrots every week. And ideally, you should have 4 every day. You can grow your own carrots by buying seeds from a nursery or a supermarket.

Sandi turns to the basket, and picks up a whole garlic. She turns to face the user, and points to the garlic while she explains the importance of this vegetable. Upon finishing the explanations, she returns it to the basket.

Sandi: The last thing for your stomach is garlic. Garlic is very good for everybody because it cleans your stomach. And it's safe to eat lots of it. You should eat 2 to 3 cloves of garlic per day. Cooked garlic is okay, but it's a lot better if you can eat it raw. Like carrots, you can grow your own.

Appendix B

Questionnaires Used

Appendix B1: The Food Safety Knowledge Questionnaire

For each question, tick the box that is next to the best answer, like this. ☐

---

1 The best way to clean your hands before preparing food is to:

- ☐ Wipe them with a wet dishcloth or towel.
- ☐ Wipe them on your clothes.
- ☐ Rinse them under running water.
- ☐ Wash them with soap and warm running water.
- ☐ Not sure.

2 Cooking eggs until both the yolk and white are firm will kill harmful germs.

- ☐ Agree
- ☐ Disagree
- ☐ Not sure

3 Using the same cutting board to cut up raw chicken and then cut raw vegetables for a salad is safe as long as you wipe the board off with a clean cloth between the different foods.

- ☐ Agree
- ☐ Disagree
- ☐ Not sure

4 After you have shaped ground beef burgers with your hands, which of the following best describes what you should do next before continuing to cook?

- ☐ Wipe your hands on a towel or cloth.
- ☐ Rinse your hands under warm running water.
- ☐ Wash your hands with soap and warm running water.
- ☐ Continue to cook without washing hands.
- ☐ Not sure.

5 If you use a dishcloth to wipe up liquid from meat or chicken, you can safely continue to use the cloth for washing dishes if you rinse the dishcloth in hot water.

- ☐ Agree
- ☐ Disagree
- ☐ Not sure

6 It is safe to use raw eggs in recipes that will not be cooked.

- ☐ Agree
- ☐ Disagree
- ☐ Not sure

For questions 7-10, indicate whether the following foods are:

"safe to eat" or should be" thrown away" if they are left out at room temperature for more than 4 hours.

7 Cooked rice at room temperature for more than 4 hours:

- ☐ Throw away
- ☐ Safe to eat
- ☐ Not sure

8 Cooked meat at room temperature for more than 4 hours:

- ☐ Throw away
- ☐ Safe to eat
- ☐ Not sure

9 A whole apple at room temperature for more than 4 hours:

- ☐ Throw away
- ☐ Safe to eat
- ☐ Not sure

10 A baked potato at room temperature for more than 4 hours:

- ☐ Throw away
- ☐ Safe to eat
- ☐ Not sure

Some foods can cause severe foodborne illness in pregnant women and persons with weakened immune systems. For the next 2 questions, indicate whether people who are at high risk for foodborne illness should "avoid" the food because it may cause severe illness or whether the food is 'okay to eat'.

11 Cold Smoked Fish:

- ☐ Avoid
- ☐ Okay to eat
- ☐ Not sure

12 Well done roast beef:

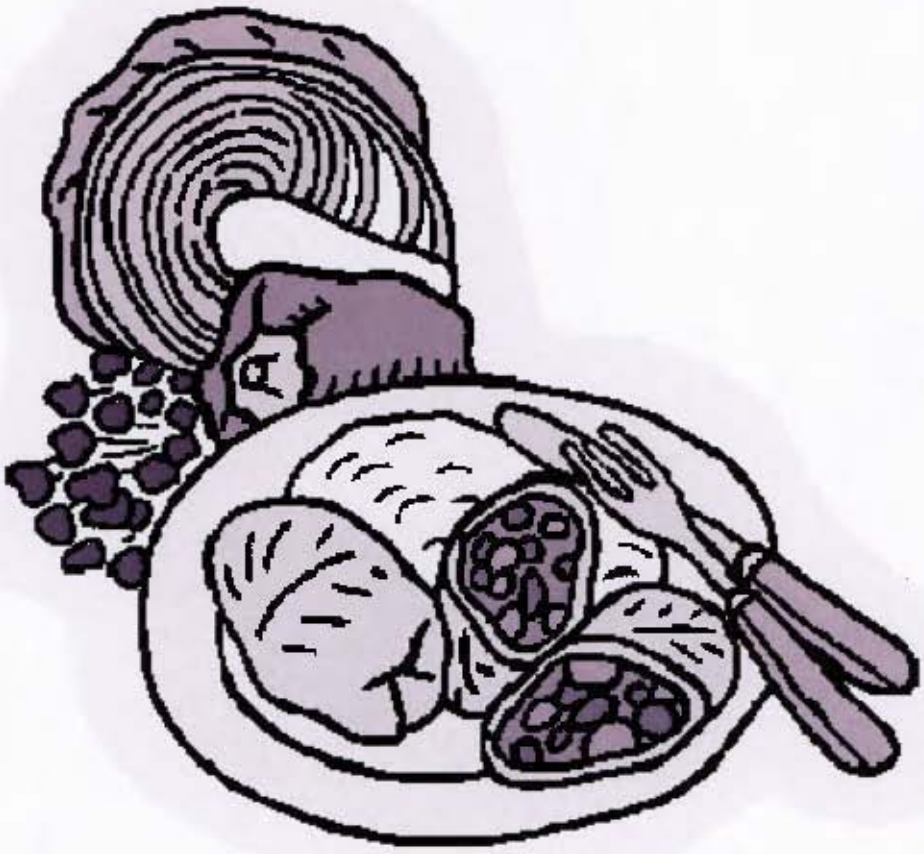
- ☐ Avoid
- ☐ Okay to eat
- ☐ Not sure

Appendix B2: The Three Day Food Diary

This document was printed out two sheets per page in black and white. It was then folded into an A5 booklet and stapled in the middle. All participants folded the booklet in half again to make it easier to keep on themselves during the data capturing days. For each of the three required days of data capture, two pages were available for entry. Because this is merely a repetition, only one day is shown here. Additionally, the cover and last pages were reserved for notes or questions. Only one is presented here. Before giving a food diary to a participant, the experimenter wrote down the three dates for data capture (on the front cover and on top of each of the days' pages) and the next scheduled meeting time. The experimenter also went through the "Hints and Tips" page as well as the example meal page.

Every participant was given two copies of this booklet: one at their 1st meeting, and one at their 2nd meeting. Data from these two booklets provided data for the pre-test and post-test points in time.

3-Day Food Diary



Day 1: _____

Day 2: _____

Day 3: _____

Next Meeting: _____

Some Hints:

- On the 3 days that you need to fill in this book, please write in **any food you ate** on that day, and **any drinks you drank** on that day. Drinks include all cooldrinks, water, fruit juice, alcoholic drinks, tea and coffee.

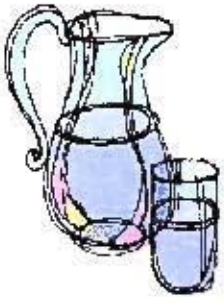
- It is very important that you be honest and tell the truth when you write in this diary. Whatever you ate or drank on the day, please put it in this book.

- If you can, try write down what you eat and drink as **you go**. If possible, don't depend on your memory at the end of the day.

- Guess the **amounts** of all the foods and drinks you had on each of the days. You can use household measures (e.g. spoons, cups, bowls), natural units (e.g. slices of bread, numbers of eggs), or fraction of packaged foods (e.g. ½ can of baked beans).

- Be as **specific** as possible, and remember to write down any extras you might have had with your food (e.g. gravy / sauce / salad dressings). If you drank tea or coffee, write down if you had milk (full cream, 2%, skim, soya, etc.) and sugar (how many teaspoons) with it.

- **Be sure to bring these completed diaries back with you to our next meeting.**



Notes or Questions:

Example of a Day:

This example is for a supper meal. Let's say you ate chicken with rice, with some fried vegetables. This is how you should write down the information in your diary:

Description of Food / Description of Drink	Cooking Method & Extra Information	Amount
White rice	Boiled	1 cup
Chicken	Grilled	1 thigh
Cheese	Grated	1 matchbox size
Carrots	Fried in oil	4 carrots
Onion	Fried in oil	½ medium onion
Tomato	Fried in oil	1 tomato
Coffee	2tsp sugar & 2% milk	1 cup
Water		1 cup

Day 1: _____

Description of Food / Description of Drink	Cooking Method & Extra Information	Amount

Appendix B3: The Specific Food Consumption Questionnaire

The following questionnaire was administered at both the pre- and post-tests points in time. Responses from this questionnaire provided data for the three **Preventative Dietary Behaviours** variables (consumption of carrots, pumpkin seeds and garlic) as well as the **Vit** variable (consumption of additional vitamins).

For each question, tick the box that is next to the best answer, like this. ☐

---

1. In the last week, did you eat any pumpkin seeds?

☐ No ☐ Yes - How much roughly? .....

---

2. In the last week, did you eat any carrots?

☐ No ☐ Yes - How many roughly? .....

---

3. In the last week, did you eat any garlic?

☐ No ☐ Yes - How much roughly? .....

---

4. In the last week, did you take any extra vitamins?

☐ No ☐ Yes

If you answered "Yes" – what vitamins did you take?

Appendix B4: The Food Diary Experience Questionnaire

1 In keeping this food diary, has it made you more aware of what you're eating in general?

2 Was it difficult keeping track of what you ate and drank on those 3 days? How did you go about keeping this diary?

3 What problems did you have when writing in this diary?

4 If money wasn't a problem, what would you add to your diet?

5 In general, did you fill in the diary after eating your meal? Or did you wait until the end of the day? Did you take it out with you when you left your home?

6 Do you think this diary is accurate? Were there any days that you forgot to take it out with you when you left your home? Or were there days that you didn't want to take it out with you?

7 Do you ever run out of money for food?

Appendix B5: The Technology Familiarity Questionnaire

For each question, tick the box that is next to the best answer, like this. ☐

---

1. Have you ever used a computer before?

☐ No ☐ Yes

- If "Yes", what have you used a computer for?

.....

.....

- If "Yes", how often do you use a computer?

☐ Once or twice only

☐ Once or twice a month

☐ Once or twice a week

☐ Everyday

---

2. Do you know what the Internet is?

☐ No ☐ Yes

- If "Yes", have you ever used the Internet? And what have you used it for?

.....

.....

---

3. Do you have any of the following items in your home?

☐ TV

☐ Video machine

☐ Computer

☐ DVD Player

Appendix B6: VE Interview Questions

The following questions were used during the semi-structured interviews conducted immediately after the nine participants each experienced the VE.

- Have you ever used a computer before today?
- If yes, what for? Do you use a computer often or just on occasion?
- Do you know what the Internet is? If yes, have you ever used it to look for information for people with HIV?
- Can I ask about the computer program you just looked at? How was that for you?
- Did you find the computer easy to use? Or was it difficult? Did you feel uneasy (at the beginning / towards the end)? Fear of damaging the computer?
- What did you like **best** about the actual house, or the people in the house, or anything else in the house?
- What did you like **least** about the actual house, or the people in the house, or anything else in the house?
- Looking at Sandi - What would you have liked her to tell you more about?
- At what point after your diagnosis would it have been useful for you to see this computer program?
- With all the HIV information in the house, did you feel excited? Or did you feel overwhelmed?
- Was the information in the house useful to you?
- Thinking of your life at the moment, do you find it difficult to get information like the stuff you saw in the house just now? If so, how is it difficult?
- Would it have been useful for you to have people in the house that you could talk to, and who could talk back to you?
- If this computer program was available all the time, at say this clinic, do you think you would come back and explore the house again? Maybe have a look at things you didn't see this time?
- Looking at this computer program, do you think a TV program or a video would have been better for you?

Appendix B7: Consent Form

The following consent form was signed by each participating experimental subject. It was administered at the beginning of the first meeting prior to completion of any questionnaires and interventions.

CONSENT FORM

I, _____, fully understand the experiment as explained to me by Sarah Brown and described in the Information Sheet, and agree to participate. I understand that all information which I provide will be kept confidential, and that my identity will not be revealed in any publication resulting from the research.

Furthermore, all recorded audio and text transcripts will be deleted after the data results have been analyzed. Your participation is completely voluntary, and you may withdraw from the project at any time.

Name: _____

Signature: _____

Date: _____

Witness: _____

Note: Recorded audio and text transcripts refer to responses to questionnaires or interviews.

Appendix B8: The Socio-demographic Questionnaire

The following questionnaire was the first questionnaire administered. At both experiment venues, a translator was available to assist with any language difficulties and clarification of questions.

For each question, tick the box that is next to the best answer, like this. ☐

Age in years

☐ 20-30 ☐ 31-40 ☐ 41-50 ☐ 51-65

Gender

☐ Female ☐ Male

Education in years

☐ Less than Std 5 ☐ Std 6-8 ☐ Std 9-10 ☐ Post Matric

Job status

☐ Full-time employed ☐ Part-time employed ☐ Unemployed

Marital status

☐ Single ☐ Have a partner

Accommodation

☐ Living alone ☐ Living with family ☐ Living with partner

Household income (per month)

☐ Less than R1000 ☐ R1001-R2000 ☐ R2001-R3000

☐ R3001-R4000 ☐ R4001-R5000 ☐ More than R5000

Number of people living in the home

☐ Number of people (including yourself)

Children in the home

☐ No ☐ Yes - how many? .....

HIV+ Child

☐ No ☐ Yes

Home Language

☐ Xhosa ☐ English ☐ Afrikaans ☐ Other

Time since being diagnosed

☐ 0-6 months ☐ 6-12 months ☐ 1-2 years ☐ More than 2 years

Stage of the disease

☐ No symptoms ☐ Symtomatic ☐ Aids diagnosis

Appendix B9: The Information Sheet for the Text Group

INFORMATION SHEET

This experiment is being conducted in connection with a research project at the University of Cape Town. The purpose of this research project is to explore different ways of communicating supportive information to people who are HIV+.

This study involves no direct risk to you, the participant – and there is an HIV counsellor on site that you will be able to talk to. The study will be conducted over 5 weeks. And we will meet 3 times during that period at this venue. Each of these meetings will take a maximum time of one hour.

At the 1st meeting, you will meet one of the two experimenters. They are Ms Mignon Coetzee, a psychologist, and Ms Sarah Brown. At this time you will be asked to fill in 2 questionnaires. The experimenter will then give you a food diary and a pen. You will be asked to write in this diary for 3 different days. The experimenter will explain how to fill in this diary.

At the 2nd meeting we will collect your completed food diary. You will then be given some papers to read on nutrition information for people living with HIV. With the help of one of the experimenters you'll be asked to complete 2 questionnaires. When you're finished with this second stage, you will be given another food diary and a pen. You will be asked to fill in this diary for another 3 different days.

The 3rd and final stage of the experiment will take place 1 month later. At this time, you will be asked to complete a questionnaire. We will collect your 2nd food diary, and will discuss any issues or problems you had during the previous month. We will also discuss the overall nature of the research project at this time.

Please feel free to ask any questions you may have during these 3 stages of the experiment, especially if there is a word, phrase or idea that you do not understand.

You will be reimbursed R200 for your participation. Thank you for your cooperation and the time that you will put into this study.

Appendix B10: The Information Sheet for the Virtual Environment Group

INFORMATION SHEET

This experiment is being conducted in connection with a research project at the University of Cape Town. The purpose of this research project is to explore different ways of communicating supportive information to people who are HIV+.

This study involves no direct risk to you, the participant – and there is an HIV counsellor on site that you will be able to talk to. The study will be conducted over 5 weeks. And we will meet 3 times during that period at Shipley Clinic in Green Point. Each of these meetings will take a maximum time of one hour.

At the 1st meeting, you will meet one of the two experimenters. They are Ms Mignon Coetzee, a psychologist, and Ms Sarah Brown. At this time you will be asked to fill in 2 questionnaires. The experimenter will then give you a food diary and a pen. You will be asked to write in this diary for 3 different days. The experimenter will explain how to fill in this diary.

At the 2nd meeting we will collect your completed food diary. With the help of one of the experimenters you'll be asked to complete 2 questionnaires. You will then be taught how to use a computer program that has been created for this experiment. When you're using this program, you will see (on the computer screen) and hear (wearing headphones) information on nutrition for people living with HIV. After the computer program, you will have an interview where we will ask you questions related to the computer program. This interview will be recorded on a cassette tape, and only your voice will be recorded. When you're finished with this second stage, you will be given another food diary and a pen. You will be asked to fill in this diary for another 3 different days.

The 3rd and final stage of the experiment will take place 1 month later. At this time, you will be asked to complete a questionnaire. We will collect your 2nd food diary, and will discuss any issues or problems you had during the previous month. We will also discuss the overall nature of the research project at this time.

Please feel free to ask any questions you may have during these 3 stages of the experiment, especially if there is a word, phrase or idea that you do not understand.

You will be reimbursed R200 for your participation. Thank you for your cooperation and the time that you will put into this study.

Appendix B11: The Information Sheet for the Control Group

INFORMATION SHEET

This experiment is being conducted in connection with a research project at the University of Cape Town. The purpose of this research project is to explore different ways of communicating supportive information to people who are HIV+.

This study involves no direct risk to you, the participant – and there is an HIV counsellor on site that you will be able to talk to. The study will be conducted over 5 weeks. And we will meet 3 times during that period at this venue. Each of these meetings will take a maximum time of one hour.

At the 1st meeting, you will meet one of the two experimenters. They are Ms Mignon Coetzee, a psychologist, and Ms Sarah Brown. At this time you will be asked to fill in 2 questionnaires. The experimenter will then give you a food diary and a pen. You will be asked to write in this diary for 3 different days. The experimenter will explain how to fill in this diary.

At the 2nd meeting we will collect your completed food diary. With the help of one of the experimenters you'll be asked to complete 2 questionnaires. When you're finished with this second stage, you will be given another food diary and a pen. You will be asked to fill in this diary for another 3 different days.

The 3rd and final stage of the experiment will take place 1 month later. At this time, you will be asked to complete a questionnaire. We will collect your 2nd food diary, and will discuss any issues or problems you had during the previous month. We will also discuss the overall nature of the research project at this time and you will be given some papers to read on nutrition information for people living with HIV.

Please feel free to ask any questions you may have during these 3 stages of the experiment, especially if there is a word, phrase or idea that you do not understand.

You will be reimbursed R200 for your participation. Thank you for your cooperation and the time that you will put into this study.

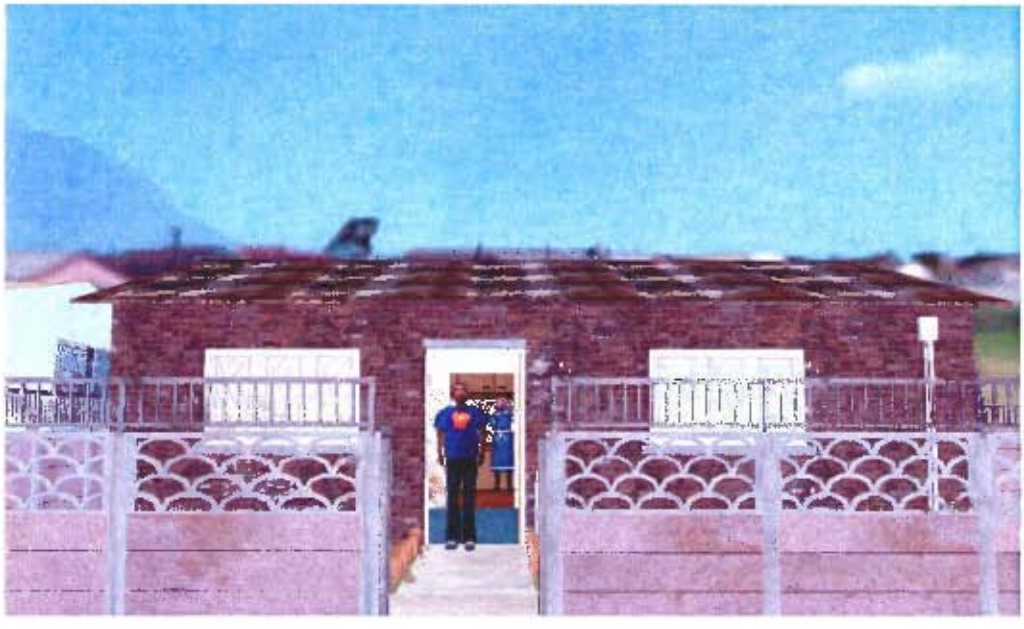
Appendix C

Text-Based Intervention Pamphlet

The following document was printed out in colour with two sheets per page, resulting in a 14 page document. It was given to every experimental subject who completed the research study. Those participants that were in the VE or Text groups were given the pamphlet at the end of the 2nd meeting. Those participants placed in the **Ctrl** group were given this pamphlet at the final (3rd) meeting. One participant requested an isiXhosa copy of the pamphlet which was made available.

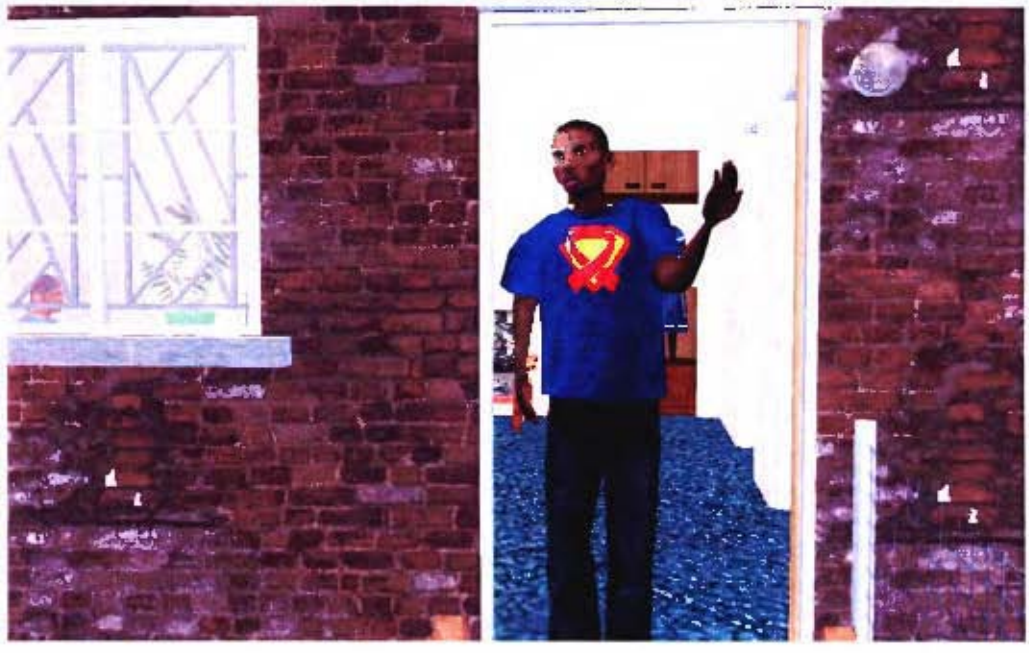
Nutrition Information Booklet:

Andile's Home



The Neighbourhood

Welcome to Andile's Home ....



Andile: Hi there, welcome to my home. My name is Andile. Why don t you come and join me and my friends inside? I think you will find it very useful.

Andile: Come along then, there are some people inside that I'd like you to meet.

Andile: Just to let you know, when you're finished visiting my house, just walk up to this door and then I'll know you'd like to leave.

The Inside of the House

The Bathroom

The Bedroom

The Lounge

Andile: This is the lounge, and through that door you'll find the kitchen. A friend of mine, Sandi, is busy in the kitchen, but you can meet her a bit later.

Andile: I would like to first introduce you to my friends here. We're all HIV positive, and meet every week to talk about how we're feeling, y'know share our feelings a bit.

Joey: Hi, I'm Joey. Please come and join us. We were talking about how to look after ourselves, with the virus and all.

Andile: And this is Pieter.

Pieter: Hello and welcome!

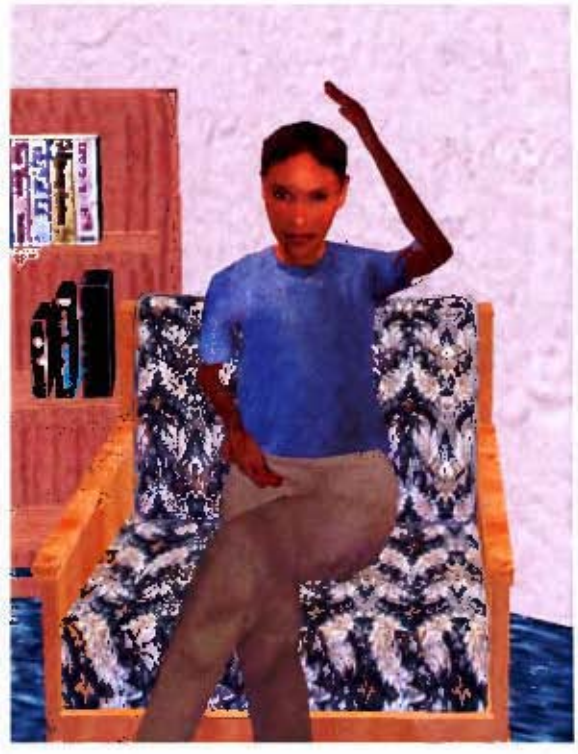
Andile: Why don't you take a seat over here?

Joey: Yes, I've just been telling them how much my life has changed since I learnt that I was HIV positive. And I don't mean a bad change, in fact, many things are so much better.

Andile: But that is not how you felt in the beginning. I remember talking to you back then and how angry and upset you felt.

Joey: It was hard in the beginning, but I think it was because I did not understand the virus well, and I did not know how to look after myself. I could only think, 'this is the end'.

Pieter: It was exactly the same for me. I am so grateful that it is all better now. I cannot imagine that I was so depressed. How did it all change for you? How did you end up feeling so happy?



Joey: In the beginning I thought the virus would get the better of me, but then I spoke to a woman at the clinic, one of the counsellors. She mentioned things about healthy living. I listened carefully and even took some literature to read. I don't think she could ever know how much she meant to me. We sat in her office and she slowly talked through everything with me. She explained how the virus works, how my immune system is like little soldiers fighting this virus. She showed me my CD4 blood count and explained how I need to keep it high. I learnt that I had to build my immune system to stay strong and healthy. I listened to what she said about exercising, eating good food, resting enough and all that stuff. It sounded good, these were things I always wanted to do anyway. I even felt a little bit excited.

Andile: I also made a big change in my life. I started living a healthy life and enjoying every day like never before. People think it is difficult to eat healthily, but it was more like an adventure.

Pieter: I remember when I started thinking about eating to keep healthy. It just seemed so difficult and expensive. Then Sandi came to my house to show me a few things I could make, and suddenly I understood it all

- this is the one thing I now do for myself and my body.

Andile: Yes Sandi is great. She's busy in the kitchen now - why don't you go and meet her. I know she's expecting you.

The Kitchen

Sandi: Hi there, and welcome to our kitchen. There are a couple of things I'd like to show you, so let me tell you what I've got here. At the sink area, I can tell you about food safety, and keeping things clean and germ-free. And then, at the wooden table in the corner is where I can tell you about the different types of foods that HIV+ people should be eating to keep them strong. Now you decide where you d like to go, and walk over to that area.

Sandi: Thanks for letting me show you around the kitchen. I hope you can start using the good foods and other information in your own life. If you want me to help again, just walk over to me.

The Kitchen – At the Table (Food Groups)

Sandi: You've chosen to look at different foods we should eat. Having good nutrition is very important for people who have HIV. It helps to keep our bodies strong and it gives us energy.

Sandi: I've arranged my stuff here into different groups, and put each group into a bowl. The food in each group is similar because they give our bodies the same types of vitamins and things.

Sandi: The bowls that have green labels are groups that are good for you. Having HIV makes our bodies weaker. So eating stuff from these green groups gives us the nutrients we need to keep strong. You can't get everything your body needs from any one group. So that's why you have to eat food from every single good group, every single day.

Sandi: When you're buying food, you should choose things from the good groups that you can afford, and would enjoy eating. It's also good to have a variety, not eating the same thing every day. It makes eating more interesting. You should try to follow good nutrition as early as possible because the sooner you start, the more likely you are to stay healthy. Having HIV can sometimes make you feel like not eating. In those times, I find it's better to have smaller meals during the day instead of big meals.

Sandi: I've also got a bowl here just for vitamins. You see, we need more vitamins than people who don't have the virus. And there are some vitamins that are very, very important which you should have every day.

Sandi: Now, why don't you choose one of the bowls, and then I can explain more about the items in that group. I'll also tell you how much of that group you should have every day.

Sandi: Go ahead, pick one of the groups.

Sandi: That s all I can tell you about this group. You can choose another food group if you like, or we can go over to the sink area.

The Kitchen – At the Table (Protein Group)

Sandi: In the protein group, we have things like meat, chicken, fish, eggs, beans, peas and lentils.

Sandi: For someone who has HIV, you should be eating 2 portions of protein every day. A portion is like 1 big piece of meat, chicken or fish, or 2 eggs, or 1 cup of beans, peas or lentils.

Sandi: Having HIV causes our bodies to lose proteins. Eating proteins is important because they help you build muscles to keep you strong. When you get an infection your body uses lots of proteins to fight it. So when you're recovering from the infection, it's good to eat lots of proteins to get your strength back. Most proteins come from meats. But meat can be quite expensive. So another way of getting proteins is by eating beans, peas or lentils. But you should add 1 tablespoon of sunflower oil to these types of proteins.

The Kitchen – At the Table (Milk Group)

Sandi: In the milk group, we have things like maas, yoghurt, cheese and obviously milk. You can have milk powder or bottled milk. They're both good.

Sandi: Food in this group is also called dairy food. We need to eat 2 portions from this group every day. A portion is like one cup of milk, or 3 quarters of a cup of yoghurt, or a big piece of cheese.

Sandi: The food here is really good for you, because they provide lots of vitamins that help to keep you healthy. Some of these vitamins are calcium, magnesium, vitamin A, some vitamin B's and zinc.

Sandi: But if you want to know more about them, I have the vitamin bowl over there.

Sandi: The food here gives your body proteins, which help build muscles. It also helps build strong bones.

The Kitchen – At the Table (Vegetables Group)

Sandi: In the vegetables group, we have things like spinach, brussel sprouts, cauliflower, carrots, pumpkin, tomatoes and squash.

Sandi: Every day we should eat 3 portions of vegetables. A portion can be half a cup of vegetables or salad.

Sandi: Vegetables give you lots of different vitamins, especially vitamins A and C.

Sandi: You shouldn't overcook your vegetables, because then you lose a lot of the goodness in them. Many people say that you should even try to eat raw veggies or you can steam them over a bowl of boiling water.

Sandi: Different coloured vegetables give our bodies different vitamins. Dark green vegetables like spinach, morag, brussel sprouts, cabbage, peas, beans and brocoli are all good for us. Orange and yellow veggies like carrots, pumpkin and squash are also great, and red tomatoes give our bodies lots of vitamin C. Carrots are one of the best vegetables for HIV+ people, so we should try to eat 3 or 4 raw carrots every day.

The Kitchen – At the Table (Fruits Group)

Sandi: In the fruits group, we have oranges, apricots, mangos, guavas, paw paws and yellow peaches.

Sandi: Every day we should eat 3 portions of fruit. A portion is either a whole fruit, or half a cup of fruit.

Sandi: Like vegetables, fruit is very good for you because they give you vitamins, especially vitamins A and C.

Sandi: You can have canned fruit if you'd like, but make sure that the fruit isn t in syrup. Syrup is full of sugar, which isn't very good for people who have HIV. You can also have a glass of fruit juice as one of your fruits for the day. But once again, make sure it's sugar-free. Also, dilute the fruit juice with water; half juice, half water because concentrated juice isn't good for our stomachs.

Sandi: Besides the fruit I have here, citrus fruits like naartjies, lemons and grapefruits are really good for you if you have HIV. They give us Vitamin C which helps fight infections. Bananas are a good fruit to eat if you are trying to put on weight. They are also very easy to eat, if you have a sore mouth, and give you lots of energy.

The Kitchen – At the Table (Energy Foods Group)

Sandi: In the energy foods group, we have nuts, seeds, potatoes, cereals, bread, rice and pap.

Sandi: Every day we should eat 5 portions of energy foods. The size of the portion depends on the actual food. One portion of energy food can be a slice of bread, a bread roll, half a cup of pasta or rice, 3/4 of a cup of cereal, or 1 tablespoon of seeds.

Sandi: Having an infection like HIV, takes energy out of your body. Eating food from this group will give you some of that energy back. Some people suggest you eat most of your energy foods earlier in the day, so that the food can give you energy for the whole day. Other food that goes into this group, are oats, ndumbi, sweet potatoes, samp, millet and sorghum.

Sandi: You can see that my bread over there is wholewheat. It's much better for us than white bread.

Sandi: Nuts and seeds are very good for people who have HIV. Sesame seeds, brazil nuts, sunflower seeds and pumpkin seeds are really good for us, but peanuts are not.

The Kitchen – At the Table (Herbs & Spices Group)

Sandi: In the herbs and spices group, we have garlic, curry powder, chillies, rosemary, mixed herbs, coriander and parsley.

Sandi: The stuff here is for flavouring your food. When you have HIV, it's common to not feel like eating. But we do need food every single day, so using different herbs can make your food tastier.

Sandi: Garlic is the absolute best herb, and you should try to eat it every day. It helps to treat different infections, especially thrush. You can cook with it, but like most fruit and vegetables, it's best to eat it raw.

Sandi: Garlic also helps to keep your stomach clean, but I can tell you more about that at the sink area.

Sandi: Non-spicy herbs like thyme, parsley, lemon, rosemary, mint and basil can make your food tastier, and a lot of them also help with digestion.

Sandi: But spicy flavouring, like curry powder and chillies, isn't very good for your stomach. Having a lot of spicy food can cause your stomach to get irritated. But having small amounts not very often is okay.

The Kitchen – At the Table (Sugars Group)

Sandi: In the sugars group, we have some chocolate, sweets, biscuits, a fizzy drink and obviously, some sugar.

Sandi: Sugar is not very good for us. It feeds thrush which is a common infection for HIV+ people. You should reduce the amount of sugar in your diet as much as possible, including the sugar in your tea and coffee. A lot of sugar can reduce the number of fighter cells in your body which can cause lots of different health problems. If you have an infection, don't have any sugar. But if you are healthy you can have a small amount.

Sandi: These other foods here aren't very good for us, because they have a lot of sugar in them. If you're really craving them, you might not be eating enough energy foods.

The Kitchen – At the Table (Fats & Oils Group)

Sandi: In the fats and oils group, we have some butter, a bottle of plant oil, and some takeaway food.

Sandi: Our stomachs' struggle when we eat fried or greasy foods. They sometimes cause diarrhoea and stomach upsets.

Sandi: A little bit of oil with your food is okay, but not too much. You should choose uncooked plant or fish oils, and not cooked oils from milk products or meat.

Sandi: A little bit of butter is also okay in your diet, and butter is better than margarine.

The Kitchen – At the Table (Vitamins Group)

Sandi: In the vitamins bowl, I have 6 different ones that are important for us. I've got Selenium, zinc and vitamins B, A, C and E.

Sandi: If you have HIV, Selenium is the most important and the most powerful vitamin. People with HIV really need to try their best to take this vitamin every single day. The cheapest way of getting it is to buy selenium pills but if you can't, then you can eat a cup of Pronutro or sunflower seeds. Or, having 1 brazil nut will give you enough selenium.

Sandi: Zinc helps your immune system work properly. You can get it from foods that are rich in proteins, but it's difficult to get enough from your food. You should rather buy zinc tablets. They're not very expensive.

Sandi: The cheapest and safest way of getting vitamin A, is by eating 3 to 4 raw carrots every single day.

Sandi: Vitamin C is found in lots of fruits, especially citrus fruits, mangos, paw-paws, guavas and tomatoes. But because the amount we need is so high, it's best to buy it from the pharmacy. The cheapest form of vitamin C is ascorbic acid, which you dilute in water.

Sandi: There are lots of different types of vitamin B. The ones we need are B12, B2, B6 and Folic Acid. They slow down the virus. You can get these vitamins from eating sardines, oysters, tuna and other dairy foods. Or you can buy general vitamin B tablets from the pharmacy.

Sandi: It's good to take vitamin E with your Selenium. This vitamin helps your immune system work properly, and can also slow down the virus.

The Kitchen – At the Sink (Cleanliness & Hygiene)

Sandi: You've chosen to learn about cleanliness and hygiene. Germs can live in food and can cause anyone to get sick. We must be safe with food because we are trying to keep ourselves, our bodies and the food we eat, germ-free.

Sandi: As you can see above the draining board, there are 3 things here. They are: "Clean Water", 'Clean Food" and "Clean Stomach". All of these are very important to know about if you or someone in your family has HIV. If you choose one of them, I will tell you more about it.

Sandi: Go ahead, choose one of the three.

The Kitchen – At the Sink (Clean Food)

Sandi: You should always wash your hands before you start making your meals, before you eat, and after going to the toilet.

Sandi: You should cook meat, fish and eggs very well. Cook it until there is no pink or red inside, especially chicken, backon and other pig meat. Your eggs shouldn't be runny.

Sandi: You should wash all food very well before you cook it. If your water isn't safe, you can add 1 cap of bleach to a basin of water and wash your fruit, vegetables, meats and eggs in that water. The bleach will evaporate so you won't taste it. Water from the South African municipality is safe, but water from boreholes, rivers or dams needs to be cleaned.

Sandi: Bloody juices from raw meat should be cleaned up as soon as possible. And make sure these juices don't mix with any other food.

Sandi: When you buy food at the shop, always check the "best before" date. If the date has passed, you need to throw it out.

Sandi: You shouldn't defrost food at room temperature. Rather put the frozen food in the fridge, in a covered container. Once your food is defrosted, you should never freeze it again.

Sandi: You should keep all the surfaces in your kitchen, all your utensils, and all your bowls and plates, clean and sterile. A cheap way of doing this, is to add 1 tablespoon of bleach to 5 litres of water, and use this solution to clean.

The Kitchen – At the Sink (Clean Water)

Sandi: It's important that your body gets enough liquid, and water is the best for you. We need to drink 2 litres or 8 cups of clean, safe water every day. In South Africa, the water from our municipalities is safe. But if your water comes from a borehole, river, lake or a well, then you first need to boil it to get rid of any germs or little insects. Then you can put the boiled water in the fridge to cool it down.

Sandi: It is not a good idea to drink alcohol if you have HIV. It isn't good for your liver, and can make your body lose extra vitamins. Alcohol is really bad if you are on medication and might cause the medicine to not work properly. Drinking alcohol often weakens your immune system, which we don't want. Also, if you've had a couple of drinks, it might make it more difficult to practise safe sex which we all have to do. Alcohol absorbs water from your body, and we don't want to lose any extra water if we can help it. Having small amounts, like 1 or 2 glasses of wine in a week should be okay, but nothing more than that. Beer (including home made beer) has yeast and sugar in it. Both of these are not good for people who have HIV.

The Kitchen – At the Sink (Clean Stomach)

Sandi: We want to keep our stomachs as clean as possible. There are 3 different things you should eat often to help with this.

Sandi: Pumpkin seeds are very good for you. So when you buy this vegetable from a shop, you mustn't throw away the seeds. Rather dry them out in a warm place and then eat them. These seeds are very good for removing bugs and worms from your stomach, so they help to clean your stomach. Once a week, you should eat a handful of the seeds.

Sandi: Carrots are also very good for you. They give you vitamin A, and are also very good for dealing with worms and other stomach bugs. At the very least, you should have 4 carrots every week. And ideally, you should have 4 every day. You can grow your own carrots by buying seeds from a nursery or a supermarket.

Sandi: The last thing for your stomach is garlic. Garlic is very good for everybody because it cleans your stomach. And it's safe to eat lots of it. You should eat 2 to 3 cloves of garlic per day. Cooked garlic is okay, but it's a lot better if you can eat it raw. Like carrots, you can grow your own.

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