

# The use of Virtual Reality in patient education: the case of chronic kidney patients

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## **Abstract**

**Introduction:** The innovating techniques of Virtual Reality (VR) have increased the use of VR in various settings. This rapid evolution of VR has allowed novel and creative solutions across clinical medicine in recent years. VR application is used in distraction therapy, clinical skills training, physical therapy and physical rehabilitation. As far as we know, there are no studies about VR in patient education. It seems that 40-80% of the medical information provided by healthcare practitioners is forgotten immediately by patients. VR may contribute to better store and recall medical information. To evaluate VR in patient education, chronic kidney patients were informed through VR about the treatment peritoneal dialysis.

**Method:** A qualitative study was executed among 23 pre-dialysis patients, and with 6 patients who already had some experiences with peritoneal dialysis. The 23 pre-dialysis patients were divided in two subcategories. The first category, 'recent pre-dialysis', was defined here as; patients who started the pre-dialysis phase in the past year. The second category, 'long-term pre-dialysis', was defined here as; patients who have been in the pre-dialysis phase for more than 1 year. Patients were exposed to the VR-intervention and afterwards asked about their experiences with virtual reality, the information and the VR-intervention in general. This information was collected by using a semi-structured interview scheme. The interviews were audio-recorded, transcribed and analysed.

**Results:** The results showed that the majority positively appreciated the VR-intervention. The VR-intervention was graded with an average of 8.1 (on a scale of 0-10). In general, the information in the VR-intervention was appreciated positively. However, after the VR-intervention the patients had some questions and mentioned that they would have liked more information about automatic peritoneal dialysis. The VR-intervention was experienced as a life-like situation. Interestingly, the patients mentioned not being distracted and were more focused on the information in the VR-intervention. As opposed to the positive findings, one-third of the patients mentioned that VR had no added value to inform them about peritoneal dialysis and that the VR-glasses were uncomfortable. The VR-intervention had impact on the patients' worries, insecurities and fears, but as well on their knowledge, reassurance and confidence. A few patients mentioned that the VR-intervention was confronting. The recent pre-dialysis patients were less positive about the VR experience, and the intervention had more impact on their worries, insecurities and fears, compared to the long-term pre-dialysis patients. Furthermore there were no noticeable differences between the recent- and long-term pre-dialysis patients.

**Conclusion:** VR in patient education seems not a one-size fits all method. Two-third of the patients highly appreciated the use of VR, while one-third of the patients seems to indicate that VR is of no added value to them. Nevertheless, it seems that VR in patient education is a valuable contribution to better restore and recall medical information. Further research is needed to investigate.

**Keywords:** Virtual reality (VR), patient education, VR-intervention, medical information, pre-dialyse patients, peritoneal dialysis

## **1. Introduction**

Virtual Reality (VR) is an innovating technique that is increasingly used in various medical settings. VR is used in distraction therapy (Sharar et al., 2008; Parsons & Rizzo, 2008), clinical skills training (Badash, Burtt, Solorzano & Carey, 2016), physical therapy and physical rehabilitation (Ma & Bechkoum, 2008). VR is not yet used in patient education. Nevertheless, it seems that 40-80% of the patient education provided by healthcare practitioners is forgotten immediately by patients (McGuire, 1996; Kessels, 2003; van der Meulen, 2008). The form or mode information is presented to the patient is highly relevant (Kessels, 2003). VR is a medium where procedural information, sensory information and behavioural instructions can be combined. It is therefore possible that the use of the VR can contribute to better store and recall medical information.

To evaluate VR in patient education, chronic kidney patients are informed through VR about the treatment peritoneal dialysis. It is important that this VR-intervention removes existing fears, barriers and ignorance about peritoneal dialysis of the pre-dialysis patients. It is important to give patients a clear image of peritoneal dialysis, so ultimately a better decision is made. Besides that, the VR-intervention might make the pre-dialysis phase more efficient. At this moment the pre-dialysis patient goes together with the nephrologists to a dialysis patients' home to show the treatment peritoneal dialysis. The purpose of the VR-intervention is: to increase the patient's knowledge, reassure patients about the dialysis, increase the patient's confidence about performing peritoneal dialysis and reduce the costs by replacing the home-visits.

To sum up, VR is an innovating technique that used in various medical settings. To our knowledge it seems that VR is not yet used in patient education. It might be that VR in patient education contributes to better restore and recall medical information, so patients will be better prepared to make a decision for a treatment. The VR-intervention should increase knowledge; reassure patients, increase the patient's confidence and reduce costs. The main objective of this study was to evaluate VR in patient education among pre-dialysis kidney patients and patients who have experience with peritoneal dialysis.

### ***1.1 Virtual Reality***

Virtual Reality (VR) can be defined as simulated reality in which a patient can experience a real situation. In general terms, VR creates 'a sense of presence in an immersive, computer-generated, three-dimensional, interactive environment' through head-mounted displays, body-tracking sensors and direct user-input devices (Gerardi, 2010). By engaging the patient through multiple sensory modalities, life-like VR situations are experienced. According to Adams et. al. (2018) the goal of VR 'is to create an entirely immersive experience that fully transports the user away from reality and into a Virtual World'.

On one hand, VR provides an easy, powerful, intuitive way of human-computer interaction (Streitz et al., 2001). Users can watch and manipulate the simulated environment in the same way that users act in the real world, without any need to learn how the complicated user interface works. VR has a naturalistic or real-life environment. The experiences of being immersed within a virtual environment allow the user to forget that they are in a testing situation. In addition, VR allows presentation of more 'dangerous' or challenging assessment situations and learns users to experience mistakes to promote learning. Besides that, VR concerns the possibility to adjust the type, number speed and sequence of stimuli that are presented. The environments can be easily adapted to personal conditions of the user, so interventions are improved.

On the other hand, VR can cause cybersickness which includes symptoms like nausea, vomiting, eyestrain, disorientation, ataxia and vertigo (LaViola, 2000). Studies investigating cybersickness reported that cyber sickness is related to sensory-cue incongruity (Young, Adelstein & Ellis, 2006; Lin et al., 2002). Sensory-cue incongruity occurs when there is a conflict between perceptions in different sense modalities or when sensory cue information in the VR environment is incongruent with what is felt by the body or with what is expected based on the user's history of the real environment sensor motor experiences (Lin et al., 2002). Besides that, VR can also cause simulator sickness. Simulator sickness can be caused by imperfect hardware, system latency and frame rate variations (Lin et al., 2002). Hardware imperfection can contribute to a sickness feeling because it might fail to provide perfect stimuli to the human sense. The sickness from system latency is caused by a mismatch between visual motion cues and the information that is sent to the brain by the vestibular system. Inconsistent frame rates may have a negative influence on the sense of presence and therefore can cause simulator sickness (Bles & Wertheim, 2000).

Although the use of VR knows positive- and negative aspects, it is increasingly used in many fields. Initially, VR was made for entertainment. However, much more applications of VR are possible because of this new emerging and growing techniques. For example, VR is used in combat training in the army (Rizzo et al., 2015), for testing products that are not yet in production (Berg & Vance, 2017), to treat eating disorders and obesity (Gutiérrez-Maldonado, Wiederhold, & Riva, 2016) and for social training (Didehbani et al., 2016). This rapid evolution of VR has also allowed novel and creative solution across the healthcare sector in recent years.

### ***1.2 Virtual Reality in healthcare***

VR is increasingly used in the healthcare sector with a variety of potential benefits for many aspects of recovery, treatment and research (Riva, 2002). Early studies suggest a growing role for VR applications in (1) distraction therapy, (2) clinical skills training, (3) physical therapy and physical rehabilitation.

VR in distraction therapy may offer a low-risk, high-efficacy approach to procedural pain management in clinical medicine (Parsons & Rizzo, 2008). Multiple studies were conducted, wherein patients underwent medical procedures both with and without VR distraction during the procedure. Results showed that the patients with VR indicated to experience less pain and that their anxiety was reduced (Wiederhold, Gao & Wiederhold, 2014; Furman et al., 2009). In addition, VR-distraction therapy has been utilized as an adjunct to narcotic pharmacotherapy in the management of burn wound care. Research showed that when VR-distraction therapy was used, the patient reported lower pain intensity, less time spent thinking about pain, decreased pain unpleasantness and increased fun, during the wound debridement (Hoffman et al, 2008). VR-based distraction therapy may provide similar benefits to patients following acute traumatic injury (Teeley et al., 2012) and oncologic treatments (Schneider et al., 2004). This might assume that the use of VR can contribute to reducing anxieties and pain.

VR in clinical training is used as an educational tool to improve mastery of procedural skills for surgery trainees (Badash et al., 2016). The studies about VR in clinical training suggest that VR-based simulation increases clinical training in both procedural medicine and interpersonal communication skills among healthcare professionals when compared to traditional education methods (Saratzis et al., 2017; Real et al., 2017). Other studies about learning in a VR-based environment do not assess the degree in which the achievement from the VR-based simulation can be used in the real world (Washburn, Bordnick & Rizzo 2017; Li et al., 2007). Future studies are needed to provide a greater understating of the potential for and limitation of VR-based training.

VR in physical therapy and rehabilitation is used to motor rehabilitation, aiding patients to require specific skills and improve body movement in virtual environments (Dascal et al., 2017). In a study which set out to determine the effects of VR in physical therapy and rehabilitation Kim, Son, Ko and Yoon (2013) found that patients performing VR exercise routines improved (hip) muscle strength and balance as compared to patients utilizing standard means of exercise. A benefit of using VR in physical therapy and rehabilitation is that the practitioners have full control over the patient's stimulus presentation and responds measurement, which leads to better-costumed programs. Overall, studies about VR in physical therapy and rehabilitation suggest a role for VR-based simulation as an addition to traditional physical therapy (Gokeler et al., 2016; Markus et al., 2009; Ma & Beckoum, 2008). Still, future research is needed to determine the feasibility of VR-based protocols and associated user training.

In the areas where VR is now used, it can be assumed that VR contributes to an improved quality of healthcare, an improved quality of life, better accessibility of healthcare and a reduction in the costs of healthcare (Brahnam & Jain, 2011). VR ensures that the total experience of patients in hospitals is experienced as more pleasant. Despite of this growing role of VR in healthcare settings, it seems that VR is not yet used for patient education.

### ***1.3 Virtual Reality in patient education***

As far as the literature showed us VR is not yet used in patient education. Based on the successful application of VR in healthcare, it is expected that patient education through VR to inform patients will be effective. Previous studies showed that VR-based simulation is established as an area that provides an effective and motivating way to help teach in several fields (Kim, Park & Baek, 2009; Riva, 2003). In the clinical medicine area, VR applications have become an alternative tool for training of medical procedures and tools to support the implementation of elaborate practices. A study showed that VR is also used in procedural information for patients. This study stated that patients have difficulties understanding the procedures (e.g. operations) they will be undergoing, which causes the problem that the patient is not fully aware of what he/she agrees with. The amount of information correctly recalled by patients is limited. It seems that 40-80% of medical information provided by healthcare practitioners is forgotten immediately (McGuire, 1996; Kessels, 2003; van der Meulen, 2008). The bigger the amount of information presented, the lower the proportion correctly recalled (McGuire, 1996). Instead of telling patients about the procedures, doctors can use VR to let the patients experience a virtual representation of the procedure that is carried out. The study of Sales, Machado and Moraes (2011) showed that VR helps to set appropriate expectations for the various stages in the procedures, in which patients better remember the information. Taken these studies into account it seems that VR in patient education is needed and might give effective results.

It is very important to provide patients with information about their treatment through the use of an efficient mode or form (Leventhal and Johnson, 1974; Hall & Roter, 2011; Green, 2013). In a study which set out to determine the effect of receiving preparatory information Leventhal and Johnson (1974) and Green (2013), found that a distinction could be made between procedural information (actual information concerning the procedural steps), sensory information (information about what the patient will hear, feel, see, smell, and taste) and behavioural instruction (information about desired behaviour in order to render a smooth procedure). Sensory information was considered to be the most valuable for anxiety reduction. Behavioural instructions would most influence the coping reaction of the individual. Providing information about treatments leads to accurate

expectations that increase the cognitive control over the upcoming events, which in its turn, decrease the damaging psychological effects. It seems that the form or mode of information presented to patients is highly relevant. A combination of sensory information and procedural information is most effective of remembering medical information. The evidence of Leventhal and Johnson (1974) and Green (2013) might suggest that VR can be used to offer patient education because in VR the sensory information, procedural information and behavioural instruction are combined. Besides that, the study of Sales et al. (2011) showed that the use of VR in procedural information sets the appropriate expectations which might be comparable to VR in medical information. The study of van Vliet et al. (2004), found that it was important for patients that the information about medical treatments was complete, correct but nonetheless that the information corresponds with the reality. In addition, van Vliet et al (2004) indicated that anxiety and stress perceived by patients while being informed, is reduced when the patient's expectations about the threatening procedure correspond with the actual experience reality. Subsequently, the studies of Olivers (2014) and Broersma (2018) showed that people learn and remember better when information is visualized. It seems that providing patients with visual information helps to better remember the information, sets appropriate expectations which leads to a reduction of anxiety and stress.

Combining the evidence of Leventhal and Johnson (1974), Green (2013) van Vliet (2004), Olivers (2014) and Broersma (2018) it is suggest that VR in patient education can be effectively used. In this study VR in patient education will be evaluated by chronic kidney patients. The chronic kidney patients will be exposed to the VR-intervention about the treatment peritoneal dialysis. The study of Keeney and McKenna (2014) found that, 25% of pre-dialysis patients did not remember receiving information about their reduced kidney function before commencing dialysis, and almost two-thirds (66%) of the dialysis patients felt that they did not receive the information needed to help them deal with their condition in everyday life. Another research showed that the majority of patients who had received the pre-dialysis education (information), seemed to have an unrealistic view of what dialysis may involve and what their survival might be (Lamping et al., 2000). The VR in patient education should ensure that pre-dialysis patients are better informed. Let's start with a short explanation about chronic kidney disease, possible treatments and existing barriers to choose for peritoneal dialysis.

#### ***1.4 Chronic kidney disease***

Chronic kidney disease is defined as constantly inadequate or not working kidneys. Almost every person has two kidneys. The kidneys serve an important organic function in our body namely, kidneys filter and regulate the blood; kidneys remove waste substances; regulate the amount of water and salts; and make hormones (these are substances that help other organs to work properly) (Nierstichting, 2018). With a chronic kidney disease, the kidney filters are damaged. The valuable substances end up in the urine and the kidneys cannot filter the blood. Common causes of kidney damage are high blood pressure, diabetes, kidney filter inflammation, arteriosclerosis, hereditary disease such as cysteine (Nierstichting, 2018). Once your kidney filters are damaged, they usually will not recover. During the past years, chronic kidney disease has emerged as a significant public health problem. More than 10% of the adult population has symptoms of chronic kidney disease or risk factors for this disease. The number of patients developing the need for renal (kidney) replacement treatment is likely to continue to grow and is expected to increase over the next decade (Keeney & Mckenna, 2014). In the Netherlands, the annual incidence of chronic kidney disease is around 1213 per 100 000 people (Blijderveen et al., 2014). This is in line

with the Nierstichting (2018), which showed that 10,6% of the Dutch population has chronic kidney disease (1,7 million people out of 17 million people).

### ***1.5 Treatments***

In the beginning, the limited function of the kidneys is initially taken care of by diet and nutrition. However, most patient, sooner or later, have to start dialysis. If the kidneys function for 20% or less, the pre-dialysis phase starts. In this study, a distinction is made between recent pre-dialysis patients and long-term pre-dialysis patients. The distinction was made based on the grieving process. The first category, 'recent pre-dialysis', was defined here as; patients who started the pre-dialysis phase in the past year. The second category, 'long-term pre-dialysis', was defined here as; patients who have been in the pre-dialysis phase for more than 1 year. Literature showed that processing the loss of someone or something takes on average 1 year (Pool, 2010; Kastenbaum, 2015; Moors, 2015). Besides that, the nephrologists indicated that when patients hear that their kidneys work for 20% or less, it has an enormous impact on them. From that moment on, the patient realises that their kidneys do not work anymore. The process to accept and to process this loss then starts. It can be assumed that this distinction between recent- and long-term pre-dialysis patients affects the results.

In the pre-dialysis phase, pre-dialysis patients are informed about possible renal replacement therapies. Three renal replacement therapies, transplantation, haemodialysis, and peritoneal dialysis, can be used for chronic kidney disease. The pre-dialysis patients have to choose between haemodialysis or peritoneal dialysis, because the list for transplantation is long; one average a kidney donation takes three to four years, and a renal replacement therapy may be needed sooner. The choice between haemodialysis or peritoneal dialysis must be made before the kidney function has reached 10% or less. It is obligated that the treatment starts with a kidney function of 10 %. In this paper, the treatments haemodialysis and peritoneal dialysis will be explained. It is important to bear in mind that these renal replacement therapies remove fewer waste substances of the blood than healthy kidneys do.

#### ***1.5.1 Haemodialysis***

Haemodialysis is defined as: an artificial kidney that filters your blood in a dialysis machine (located in the hospital). With this treatment, the patient will be reimbursed on the artificial kidney (machine) three to four times a week; with a duration of three to four hours each time. This machine is connected to a vein, through a vascular access (shunt) that is installed in the arm of the patient during an operation. This shunt is necessary because a normal blood vessel would easily be damaged and quickly clogged. The shunt provides sufficient blood flow during dialysis, so the blood can flow through the artificial kidney. It filters fluids and waste substances in the blood. Haemodialysis is physically demanding because large fluctuations in blood values and moisture levels can occur. This physical demand might include; fatigue, a feeling of sickness and eventually damage to the heart and blood vessels (Nierstichting, 2018). It seems that it takes on average six hours to recover from a haemodialysis session (Harilall, 2008). Meaning that haemodialysis is an intensive treatment form for patients.

#### ***1.5.2 Peritoneal dialysis***

Peritoneal dialysis is defined as: a continuous home-based therapy where a peritoneum is used as a filter (Brown et al., 2010). The peritoneum lies around the abdominal organs and contains many small blood vessels. Through a small operation, the patient gets a catheter through the abdominal wall in the abdominal cavity. By the catheter,

fluid flows into the peritoneum with a moisturizing effect. This fluid filters the waste substances in the patients' blood. When the fluid is saturated and no longer has an absorbing function, it is replaced. The peritoneal dialysis takes place four times during the day and can be performed anywhere in a sterile environment, often in the patients' home. A classic example of times to dialyse is at 08.00 am, 12.00am, 17.00 pm and 22.00 pm. The duration of each changing moment is 30 – 45 minutes (Nierstichting, 2018). Advantages of the peritoneal dialysis are: the patient can decide for themselves where to dialysis (e.g. school or work); peritoneal dialysis can be effectively integrated into the patients' life; and no weekly visits to the hospital. Meaning that peritoneal is a less intensive treatment for patients

#### *Automated peritoneal dialysis*

Automated peritoneal dialysis is another type of peritoneal dialysis. Automated peritoneal dialysis is defined as: a home treatment where the machine automatically filters during the night. This treatment uses the same peritoneal catheter and same peritoneal cavity as peritoneal dialysis. The automated peritoneal dialysis machine is programmed to control how much fluid goes in and out via the catheter and how often this happens. Whereas peritoneal dialysis takes place during the day, automated peritoneal dialysis takes place during the night when the patients is a sleep (Kathuria & Twardowski, 2009). Automatic peritoneal dialysis is in most hospitals only used as a follow-up of peritoneal dialysis, mostly after 4-6 weeks. Despite that peritoneal dialysis is an easy and less intensive treatment, most patients choose for haemodialysis.

#### ***1.6 Barriers and considerations to choose for peritoneal dialysis***

Compared with haemodialysis, peritoneal dialysis might offer an improved quality of life and has economic benefits (no use of hospital and care) (Walker et al., 2015; Troidle, Bhargava, Kitsen & Finkelstein, 2010). Nevertheless, the uptake of peritoneal dialysis remains low around the world. This may be partly due to patients' lack of knowledge and barriers to shared and informed decision-making (Walker et al., 2015).

A longitudinal study of Liu et al. (2015) reports that pre-dialysis patients experience various barriers to peritoneal dialysis. Experienced barriers to peritoneal dialysis were: social and physical support at home, impaired dexterity, insufficient space to store equipment and supplies, and home modifications to make home dialysis possible. To better understand the patient's experiences and beliefs when considering peritoneal dialysis Chanouzas, Ping, Fallouh and Baharani (2011), Lauder et.al. (2010) and McLaughlin (2008) analysed which factors are important, when choosing for a renal replacement therapy. The results of these studies identified five main factors namely: (1) lacking decisional power, (2) sustaining relationships, (3) reducing lifestyle disruption, (4) gaining confidence in choice and (5) maximizing survival. Each factor can be divided into sub-themes (Table 1). The perceived barriers and considerations for peritoneal dialysis should be taken into account before the devolvement of the VR-intervention for pre-dialysis patients.

Table 1

*Perceived barriers and considerations of pre-dialysis patients when considering peritoneal dialysis*

Factors	Sub-elements
<i>Lacking decisional power</i>	Complexity of information Limited exposure to home dialysis Feeling disempowered/ not getting all the information No opportunity to choose for PD
<i>Sustaining relationships</i>	Maintaining cultural involvement Family influence / family support Trusting clinicians
<i>Reducing lifestyle</i>	Social isolation/ impaired dexterity Sustaining employment Avoiding relocation/ home modifications Considering additional expenses Seeking flexible schedules/ no distance to the hospital Creating free time/ flexible/ independent
Gaining confidence	Guarantee of safety Depending on professional certainty Reassurance from peers/ social support Overcoming fears of infections
Maximizing survival	Increased quality of life

(Source: *Lauder et al., 2010; Chanouzas et al., 2001; McLaughlin 2008; Lie et al., 2015*)

**1.7 Purpose of this study**

In this study, VR in patient education is evaluated with an VR-intervention for chronic kidney patients to inform them about peritoneal dialysis. The VR-intervention should increase knowledge; reassure patients, increase the patient's confidence and reduce costs (replacement home-visits).

The main objective of this study was to evaluate the VR-intervention for chronic kidney patients (pre-dialysis patients and patients who have experience with peritoneal dialysis). The following research question can be addressed: 'What are the experiences of (pre) dialysis patients with the VR-intervention?'

The following sub-questions can be addressed:

- What is the perceived appreciation of the VR-intervention in general according to patients?
- What is the perceived appreciation of the information according to patients?
- What is the perceived appreciation of the VR experience according to patients?
- What is the perceived impact of the intervention, in terms of knowledge, reassurance and confidence, according to patients?
- What are suggestions for improvement of the VR experience and intervention according to patients?
- What are the differences between recent pre-dialysis and long-term pre-dialysis for the perceived appreciation of the VR-intervention, information, VR experience, the perceived impact of the intervention and suggestions for improvements?



## 2. Method

To evaluate the experiences of the VR-intervention, a qualitative study was executed with pre-dialysis kidney patients, and with patients who already had some experiences with peritoneal dialysis. Information was collected using semi-structured interviews.

### *2.1 Procedure and participants*

The first group in this study were pre-dialysis patients. For participation inclusion criteria included: the right timing in the pre-dialysis phase and exclusion criteria included: not too emotional about the loss of the kidneys (mostly pre-dialysis patients who had just heard about their kidney loss). The Deventer Hospital looked at the number of their pre-dialysis patients who were suitable to participate in this study. The nephrologists briefly analysed the medical history of all patients. A selection of fourteen pre-dialysis patients was made. To enlarge this group of pre-dialysis patients other hospitals in the surrounding areas were approached to participate in this study. Other hospitals that participated in this study were Isala Hospital (Zwolle), Gelre Hospital (Apeldoorn) and Slingeland Hospital (Doetinchem). In total twenty-four patients were contacted through telephone or face-to-face by their nephrologists in the various hospitals (Deventer, Apeldoorn, Zwolle & Doetinchem) and informed about a new VR-intervention, followed by an invitation to participate in this study. After patients accepted the invitation, an appointment (mostly combined with an existing appointment in the hospital) for the use of VR was made. One patient could not participate because of acute hospitalization. In total twenty-three pre-dialysis patients (11 males, 12 females, mean age 67 years), of which 12 recent pre-dialysis patients and 11 long-term pre-dialysis patients, participated in this study.

A second group, dialysis patients who had experiences with peritoneal dialysis were too approached by telephone or face-to-face by the nephrologists in the various hospitals (Apeldoorn & Zwolle) to participate in this study. After the patients accepted the invitation, an appointment for the use of VR was made. In total six dialysis patients (5 males, 1 female, mean age 63 years) participated in this study. This study was approved by the Ethical Commission at the University of Twente, the Board of Directors of Deventer Hospital and a not-WMO pronouncement was given by METC (Medische Ethische Toetsings Commissie).

First, the patients used the VR-intervention (see next paragraph for a detailed description). Secondly, the interviews were conducted. The interview scheme was pre-tested with one pre-dialysis patient. The aim of the pre-test was to optimize the interview scheme before conducting the interviews. The pre-test was not included in the research results.

Before the start of the interview, the patients were emphasized that they had the right to withdraw the interview and that there were no good or wrong answers. In addition, it was stated that the patients had the right not to answer any questions, regardless of their reasons for it. Furthermore, the anonymity of the patients was assured. Followed by the request for their permission to record the interview. After the patients agreed on these conditions and signed the informed consent, the interview started. All interviews were audio-recorded and transcribed. The interviews took between 20 – 45 minutes, with an average duration of 30 minutes. Quotations appearing in this article have been translated from Dutch into English.

## 2.2 VR-intervention

### Functionalities

The VR headset is a type of eyewear which functions as a display device. The VR in this study enables the patient to view a three dimensional video, which shows them an illusion of depth. The VR replaces the patients natural environment with a VR content about the treatment peritoneal dialysis, that allows the patient to turn and look around, just as in the physical world.

### Content

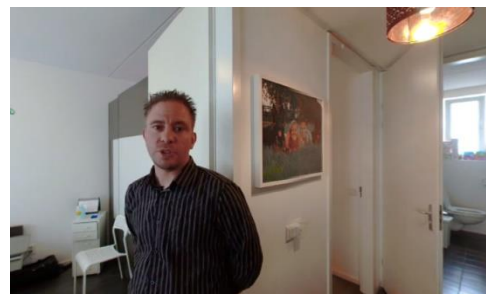
In the VR-intervention the dialysis patient Martin arrives on his motorcycle. This is followed by an introduction about himself. If you look around you can see his wife and child playing together and his two dogs. In the second scene, a delivery is made by Baxter Healthcare. Baxter Healthcare supplies medical products and services to hospitals and healthcare institutions in the Netherlands. They deliver a pallet of materials for the dialysis. Next, Martin walks to his room, where he performs the dialysis. He carries out all the actions step by step. First, everything is cleaned. Secondly, an empty bag is attached to the catheter in his stomach. Then the catheter is opened and the fluid runs out of his stomach. Finally, when his stomach is emptied, he connects a new bag to the catheter so new fluid flows in. The dialysis is finished. He appoints the fact that you can go on vacation easily. After this, he gives a short explanation about automatic peritoneal dialysis. During his treatment he tells about his experiences, prior considerations to peritoneal dialysis, fears, benefits and the impact on his daily life. This VR-intervention has a duration of 10 minutes. Figure 1 shows some screenshots of the VR-intervention.

Figure 1

### Screenshots of the VR-intervention



Introduction



Dialysis room



Delivery of the equipment for the dialysis



Cleaning before the dialysis starts



The fluid goes out the stomach



The fluid goes in the stomach



It is possible to go on vacations



Automatic peritoneal dialysis

### 2.3 Instrument

A semi-structured interview scheme was used. The questions of this scheme related to the following themes; the appreciation of the VR-intervention in general, the appreciation of the information and the appreciation of the VR experience, the impact of the intervention and the patients gave suggestions for improvements for the VR experience and intervention. The questions related to these topics were designed to be open-ended, which provided opportunities to ask follow-up questions and focus on new themes that appeared. The last part of Table 2 provides some examples of these questions. The complete interview scheme can be found in Appendix A.

Table 2

#### *Example questions for each topic*

Topics	Example questions
Appreciation of the VR-intervention in general	Which grade do you give this VR-intervention? What did you think of the VR-intervention? Do you recommend the VR-intervention to others?
Appreciation of the information	What was the most useful information? Did it raise questions? Which information did you miss?
Appreciation of the VR experience	What did you like about the VR aspect? What did you dislike about the VR aspect?
Impact of the intervention	Did the VR-intervention in any sense reassure you? Or increase worries? Did it provide you with new knowledge?
Suggestions for improvements for the VR experience and intervention	Do you have improvements for the VR-intervention?

### 2.4 Analysis

A multistep content-analytic procedure was applied to analyse the qualitative data. After the interviews were transcribed, the interviews were coded in order to acquire basic insights into the content. The main concepts of the interview scheme were used for this coding session: appreciation of the VR-intervention in general, appreciation of the information, appreciation of the VR experience, impact of the intervention and suggestions for

improvements. After this first coding session, the codes were discussed with the supervisors of the University of Twente. This was followed by a second coding session, where the codes were redefined, and also discussed with the supervisors. Finally, a third coding session was carried out, where the codes were subcategorized, and discussed with the supervisors. In other words, deductive and inductive coding took place to analyse the data.

### 3. Results

In the following paragraph, the characteristics of all participants are depicted (3.1). Followed by, appreciation of the VR-intervention in general (3.2), appreciation of the information (3.3), appreciation of the VR experience (3.4), impact of the intervention (3.5) and suggestions for improvements (3.6). At the end of each paragraph, the experiences of the dialysis patients who had experiences with peritoneal dialysis ( $N = 6$ ) will be included.

#### 3.1 Characteristics of the participants

Table 3 shows the characteristics of all patients.

Table 3

*Characteristics of the participants*

		<i>Recent pre-dialysis (n = 13)</i>	<i>Long-term pre-dialysis (n = 12)</i>	<i>Total Pre-dialysis (N = 23)</i>	<i>Total Dialysis patients (N = 6)</i>	<i>Total All patients (N = 29)</i>
Gender	<i>Man</i>	5	6	11	5	16
	<i>Female</i>	7	5	12	1	13
Age	<i>&lt;50 years</i>	1			1	2
	<i>50-60 years</i>	1		4	1	5
	<i>60-70 years</i>		2	2		2
	<i>70-80 years</i>	5	5	12	4	16
	<i>&gt;80 years</i>	1	2	3		3

#### 3.2 Appreciation of the VR-intervention in general

The appreciation of the VR-intervention in general can be divided into grades for the VR-intervention (3.2.1), perceived aspects of the VR-intervention (3.2.2) and recommendations for the VR-intervention (3.2.3).

##### 3.2.1 Grades for the VR-intervention

In general, the VR-intervention was graded positively. The majority evaluated the VR-intervention with an 8 or higher on a scale of 0-10 (Table 4). On average, this VR-intervention gets an 8.1. The long-term pre-dialysis patients evaluated the VR-intervention with a higher grade on average than the recent pre-dialysis patients. Furthermore, there are no noticeable differences between the recent- and long-term pre-dialysis patients.

Table 4

*Grades for the VR-intervention by pre-dialysis kidney patients (N = 23)*

Grades	Recent pre-dialysis (n = 12)	Long-term pre-dialysis (n = 11)	<b>Total</b> (N = 23)
6		1	<b>1</b>
7	4		<b>4</b>
7.5	1	1	<b>2</b>
8	4	6	<b>10</b>
9	2	3	<b>5</b>
10	1		<b>1</b>
<b>Mean</b>	<b>7,4</b>	<b>8</b>	<b>8,1</b>

The dialysis patients (N = 6) who had experiences with peritoneal dialysis (not in table) graded the VR-intervention with an average of 7.8.

### 3.2.2 Perceived aspects of the VR-intervention

Overall, the patients were positive about the VR-intervention (Table 5). Positive remarks related to (1) the understandability of the information (2) the completeness of the information, (3) interesting content (4) and informative content. Only a few negative remarks were mentioned and could be divided into three themes (1) the VR-intervention is overwhelming, this is illustrated by the following quotation, *'It was too much information. It would be better for me to process the information in pieces (R3)*, (2) the information was not complete, (3) and the information was not understood. The long-term pre-dialysis patients indicated more often that the VR-intervention was understandable. Furthermore, there were no noticeable differences between recent- and long-term pre-dialysis patients.

Table 5

*Perceived aspects of the VR-intervention by pre-dialysis kidney patients (N = 23)*

	Recent pre-dialysis (n = 12)	Long-term pre-dialysis (n = 11)	<b>Total</b> (N = 23)	Example quotes
<b>Positive</b>				
Is clearly understandable	4	6	<b>10</b>	'It is clear to understand how the action should be performed'(R16) 'It is clearly told what you should do (R14)'
Gives a total image	4	3	<b>7</b>	'It gives a total image of the PD treatment'(R5) 'Everything is explained step by step (R8)'
Is interesting	3	4	<b>7</b>	'Interesting how everything works (R4)' 'It is interesting that it is such an easy treatment (R12)'
Is informative	2	1	<b>3</b>	'Now you know what PD is (R19)'
<b>Negative</b>				
Overwhelming	1	1	<b>2</b>	'It is too much information (R13)'
Not a total image	1	1	<b>2</b>	'There should be more attention in the film for the difference between the treatments'(R6) 'For people who see it for the first time it is no added value, too rosy (R12)'
Not clearly understandable	1		<b>1</b>	'I thought the actions would be easier to understand and preform (R7)'

The remarks of the patients who had experience with peritoneal dialysis (N = 6) (not in table) correspond with the remarks of the pre-dialysis patients. The dialysis patients found the VR-intervention understandable and were positive about the completeness of the VR-intervention. This is illustrated by, *'How all actions have to be performed is told properly (R04)'* and *'He showed everything clearly, I think this is beneficial for others (R03)'*.

### 3.2.3 Recommendations for the VR-intervention

All patients ( $N = 23$ ) would recommend the VR-intervention to other pre-dialysis patients. Reasons for this were: (1) it gives a realistic image (2) it is a good preparation method (3) it contributes to making a choice (4) it can reassure other patients. These reasons are illustrated by the following quotations:

*'It is clear, it gives you the feeling that you are present and what you can expect (R2)', 'It is a good preparation for people who have trouble understanding (R3)' and 'You can make a better choice (R9)'*

The majority of the patients would recommend hospitals to use VR in patient education for other chronic disease. The patients reported that (1) VR is an added value for them, (2) an accessible system for everyone, (3) a modern way to give information, (4) and VR is a good way to prepare patients. These reasons are illustrated by the following quotations, *'I think it is an accessible system for everyone (R3)'* and *'It is an added value because you are confronted with the facts and really have the experience (R7)'*. There were no noticeable differences between recent- and long-term pre-dialysis patients.

The dialysis patients ( $N = 6$ ) who had experiences with peritoneal dialysis would recommend the VR-intervention to pre-dialysis patients. Five dialysis patients would recommend hospitals to use VR in patient education for other chronic diseases. One dialysis patients had no opinion about the use of VR in patient education for other chronic diseases.

### 3.3 Appreciation of the information

In general, the information is positively appreciated by the pre-dialysis patients. All pre-dialysis patients remarked the information as useful (Table 6). The majority mentioned being sufficiently informed about peritoneal dialysis. Nevertheless, the information raised some questions. The pre-dialysis patients had questions about (1) treatment, (2) the possible locations to carry out the dialysis, (3) and the diet during the treatment. Besides the positive appreciation of the information by the pre-dialysis patients, the majority indicated to miss information about the automatic peritoneal dialysis (APD). However, the automatic peritoneal dialysis was shortly mentioned, the patients would like to know more about this. This is illustrated by the following quotation, *'I want to know more about APD because this takes place at night when you are asleep so this method enriches your freedom (R.10)'*

The recent pre-dialysis patients mentioned being more sufficiently informed than the long-term pre-dialysis patients. The long-term pre-dialysis patients indicated more often that they missed information about automatic peritoneal dialysis. Furthermore, there are no noticeable differences between recent- and long-term pre-dialysis patients.

Table 6

*Appreciation of the information by pre-dialysis kidney patients (N = 23)*

	Recent pre-dialysis (n = 12)	Long-term pre-dialysis (n = 11)	<b>Total</b> (N = 23)	Example quotes
<b>Is useful</b>	12	11	<b>23</b>	
<b>Satisfaction about the information:</b>				
Sufficiently informed	9	7	<b>16</b>	
Doubts about sufficiently being informed	2	2	<b>4</b>	
Not sufficiently informed	2	1	<b>3</b>	'It is useful if someone really explains it when you really have to do it (R23)'
<b>Still questions after the information about:</b>				
Treatment	1	3	<b>4</b>	'Do you have to clean that tube at the belly? (R7)'
Places	1	2	<b>3</b>	'Is it possible in the caravan? (R5)'
Diet	2		<b>2</b>	'What about nutrition? (R12)'
<b>Missed information about:</b>				
Automatic peritoneal dialysis	6	8	<b>14</b>	'I would have liked that the last part about the machine got more attention (R3)'
Difference between HD and PD		1	<b>1</b>	'To make a better choice show the advantages and disadvantages of each treatment (R6)'
Impact on social life		1	<b>1</b>	'I would have liked to see the social impact of this treatment (R6)'.

The dialyse patients who had experiences with peritoneal dialysis had more negative remarks about the appreciation of the information (not in table). According to them, the information does not entirely correspond with the reality and pictures a too optimistic view. Negative remarks were: (1) the duration of the dialysis takes longer, (2) no time to prepare the dialysis is mentioned, (3) the bags for the dialysis have to be warm, (4) you have to shake the bags, (5) the hygiene of the tube in the stomach misses, (6) and finally you have to administer everything. These remarks can be illustrated by the following quotation, *'It is the background information that you miss in this film (R05)'*. The dialysis patients who had experiences with peritoneal dialysis also missed information about automatic peritoneal dialysis.

### **3.4 Appreciation of the VR experience**

Overall the patients appreciated the VR experience positively (Table 7). The majority had positive remarks about the immersive of VR. Patients substantiated this with; you are able to look around, it feels like you are present with him and are doing this treatment with him, and it gives you a realistic image even more than a tv does. Another positive aspect that was mentioned by the patients was that you are not distracted from your environment. This is illustrated by the following quotation, *'I am more focused on the information (R1)'*. A logical follow-up of is that the patients indicated to store the information better. Other positive aspects were, the VR is of high quality, the glasses are comfortable, easy to use and compact, for the preparation of choosing a treatment you do not have to visit another dialysis patient at home and it is much better than TV.

One-third of the patients mentioned that VR is of no added value for them. Other related negative remarks were (1) the glasses are uncomfortable, (2) it is not possible to look together, (3) it is not immersive; just a normal film, (4) when the glasses are on, it is smothery, (5) dizzy during the VR-intervention (cybersickness), (6) low quality, (7) distracted by the VR-function, (8) and disturbed locomotion (simulator sickness).

The long-term pre-dialysis patients mentioned more positive remarks about VR. The long-term patients especially indicated to store the information better by the use of VR and VR is a replacement for the home visits by another dialysis patient. Noticeable, recent pre-dialysis patients were more negative about VR. For them, VR had no added value, the glasses were uncomfortable, it was smothery and their partners could not look with them.

Table 7

*Appreciation of the VR experience by pre-dialysis kidney patients (N = 23)*

	Recent pre-dialysis (n = 12)	Long-term Pre-dialysis (n = 11)	<b>Total</b> (N = 23)	Example quotes
<b>Positive</b>				
Is immersive	9	8	<b>17</b>	'You are completely in it (R15)' 'You are capable of starting to talk with him (R16)' 'I had the idea that we did it together (R20)'
Not distracted	8	5	<b>13</b>	'It is of your with hem in the room, you do not have a cup of coffee, but otherwise you are on a visit (R21)' 'You are more focused with these glasses (R7)' 'You keep your thought with the film, that's not the case with a normal tv screen (R11)' 'No distraction (R15)'
High Quality	4	4	<b>8</b>	'The image is pretty sharp (R22)' Good sound, clear image (R8)'
Store information better	1	4	<b>5</b>	'I think you store the information better (R20)' 'You pay more attention to the information (R18)'
The glasses are comfortable	1	4	<b>5</b>	'It sits comfortable, you look away and you do not notice that you have glasses (R21)' 'it is soft on the inside (R23)'
Is compact	3	1	<b>4</b>	'It is compact, you can do it anywhere (R6)'
You do not have to go anywhere		4	<b>4</b>	'It is beneficial because you do not have to go look by someone at home (R18)' If I would go look by another patient at home, then I feel like I am looking at someone's fingers (R20)'
Better than the television	2	2	<b>4</b>	'I think this is much better than TV (R9)'
<b>Negative</b>				
No added value	6	2	<b>8</b>	'The nice image of a TV is better (R11)' 'I prefer a bigger screen (R22)'
Uncomfortable	6	2	<b>8</b>	'The glasses are too heavy (R19)' 'It is a bit uncomfortable, too tight around the head (R7)' 'The glasses drop (R1)'
You cannot look together	4		<b>4</b>	'I can't say to my partner and kids, 'look at this', so they have an idea of what is going to happen to me (R19)'. 'You have only one glasses, so it is not possible that someone else looks with you (R10)'
Non-immersive	2	1	<b>3</b>	'I do not have the feeling I am there, it is just a film (R12)'
Smothery/muggy	3		<b>3</b>	'It is sweaty (R11)' 'It was smothery, at the end I wanted to take the glasses of (R12)'
Cybersickness	2	1	<b>3</b>	'I am a little bit dizzy(R22)'
Low quality	1	2	<b>3</b>	'I found the sound a bit less and the information that came through was disturbing; 'Your Wi-Fi failed you have to press this or something'(R6)'
Distraction		1	<b>2</b>	'It is nice to look around but it does not contribute to the information (R8)' You have to focus on the film, but the virtual reality helps to distract you (R6)'
Simulation sickness			<b>1</b>	'I was a little disrupted when I took the glasses off (R10)'

The dialysis patients (N = 6) who had experiences with peritoneal dialysis (not in table) were in general positive about VR. Positive aspects were: the immersive feeling and no distraction. For the dialysis patients VR was seen as an advantage because you do not have to go to another patients' home to see the treatment peritoneal dialysis. Nevertheless, it was indicated by a few patients that the glasses were uncomfortable. One patient experienced symptoms of cybersickness.



### ***3.5 Perceived impact of the intervention***

The intervention had a positive impact on the pre-dialysis patients. The patients indicated that they gained knowledge about the hygiene and the treatment, were reassured about their freedom, easiness of the treatment and places to dialysis, and gained confidence about performing the treatment (Table 8). It appeared that the patients before the intervention had other ideas and expectations about peritoneal dialysis than after the intervention. This is illustrated by the following quotation, *'I did not expect that it is only four times a day that you have to dialysis (R1)'*.

Despite the positive impact, the intervention had a higher negative impact on the pre-dialysis patients. The negatively perceived impact could be divided into five themes; worries, insecurities, confrontations, fears and aversions. Whereas the intervention thus had been reassuring (in some aspects) for some patients, for others the intervention appeared to have increased their worries. The worries related to the treatment itself, the learning aspect of the treatment and their freedom in daily life. This is illustrated by the following quotations,

*'Every time again the actions, disinfecting and doing something like that, that was a lot. I thought it was a lot ( R4)* and *'I do not think that I can perform all those actions (R20)'*.

Other perceived impacts were that the pre-dialysis patients were insecure to start with the treatment, confronted about the needed equipment to dialysis, feared about whether it all goes well during the dialysis, and aversion against the illness.

The recent- and long-term pre-dialysis patients both indicated almost as much positive statements about the intervention. Nevertheless, the recent pre-dialysis patient reported almost twice as many negative statements in response to the intervention. The recent pre-dialysis patient had more worries about the treatment, had more insecurities about the start of the treatment and were more confronted about the delivery, their illness and treatment, then the long-term pre-dialysis patients.

Table 8

Perceived impact of the intervention by the pre-dialysis patients (N = 23)

	Recent pre-dialysis (n = 12)	Long-term pre-dialysis (n = 11)	Total (N = 23)	Example quotes
<b>Positive</b>				
<b>Knowledge about:</b>				
-Hygiene	6	5	11	'I did not know you had to disinfect so much (R17)' 'I now know that the hygiene is really important (R19)'
-The treatment	5	6	11	'The treatment is much easier than I thought before (R12)'
<b>Reassurance about:</b>				
-Freedom	5	4	9	'You have much freedom during the day (R18)'
-The treatment	3	5	8	'The treatment seems easy (R10)'
-Home dialysis	4	3	7	'it is more comfortable that you can do this at home (R8)'
-Holidays	3	3	6	'the fact that you can go on a holiday is nice (R2)'
-No use of needles	2	3	5	'I am glad that you do not have to get shots with a needle (R9)'
-Learning the steps	3		3	'It seems easy to learn (R16)'
-Not having to start		1	1	'the doctor said that I do not have to start soon (R21)'
<b>Confident about:</b>				
-The treatment			3	'It strengthens you in the thought that it is easy to perform (R2)'
<b>Negative</b>				
<b>Worries about:</b>				
-Complexity of the treatment	8	5	13	'What a hassle every time (R5)'
-Learning the steps	3	5	8	'It seems difficult to learn, all those steps (R1)'
-Inhabitation of freedom	3	4	7	'You have less freedom during the day (R19)' 'It takes a lot of time (R9)'
-Adjustments in daily life	2	2	4	'How should I dialyse at work? (R14)' 'What is the impact on my social life? (R6)'
-Hygiene	1	1	2	'It is a lot of steps to get the hygiene good (R7)'
-Holiday		2	2	'How is it possible to go on vacation with a little box compared to all the stuff in your home? (R3)'
-home dialysis	2	1	3	'Where in my home should I dialysis? (R6)'
<b>Insecure about:</b>				
-Start	8	4	12	'I am not reassured, I hope that we will not be here for a long time (R7)' 'I am insecure when I have to start (R21)'
-Infection	2		2	'No, who ensures me that I do not get infections in my stomach? (R12)' 'What is there is a tube broke (R19)?'
<b>Confronted about:</b>				
-Delivery	11	1	12	'My god, do you really need a pallet? (R6)' 'I do not have space (R16)'
-Illness	4	1	5	'It is intense because you are being pushed to the fact that you are ill (R7)'
-Treatment	3		3	'It are not little bags, but really big bags (R11)'
<b>Fears about:</b>				
-Start		1	1	'I am scared to start the dialysis (R21)'
-Treatment	2	1	3	'I am scared if everything during the dialysis goes well (R12)' 'I am feared to dialysis ( R1)'
<b>Aversion about:</b>				
-Illness		1	1	'I do not have accepted the fact that my kidneys do not function (R3)'

Half of the dialysis patients (N = 6) who had experiences with peritoneal dialysis (not in table) reported to be more positive after the start of peritoneal dialysis then before the start of peritoneal dialysis. This is illustrated by the following quotation,

*'The changes are not too bad, I am especially positive about the effect. You do not have any troubles, you feel great ( R05)'*.

The other half reported to be more negative after the start of peritoneal dialysis. Those patients reported statements about the pain of the operation and the infections. Two of them got infected and were not able to proceed with peritoneal dialysis. Other remarks after the start were: (1) the dialysis takes a lot of time, (2) going on a vacation is not easy, (3) and you cannot lift heavy stuff.

### *3.5.1 Decisions for peritoneal dialysis before and after the VR-intervention*

Before the VR-intervention nine of the pre-dialysis patients had made the decision to choose for peritoneal dialysis. After the VR-intervention this number of patients increased to fourteen pre-dialysis patient who had made the decision to choose for peritoneal dialysis. Those patients had positive remarks about peritoneal dialysis, namely (1) I prefer that you can do this at home, (2) you retain your freedom, (3) it is easy, (4) and you do not have to go to the hospital. This is illustrated by the following quotations, *'Yes, you can still do everything (R21)'* and *'You do not have to go to the hospital and all that stuff (R20)'*. Nevertheless, before the VR-intervention five patients were unsure about their decision for peritoneal dialysis and after the VR-intervention seven patients were unsure about their decision. Those patients could not yet make a decision. This is caused by their process to accept the illness. This is illustrated by the following quotation, *'I have to choose from two evils, so I do not know yet (R12)'*. There was one patient before the VR-intervention who made the decision not to choose peritoneal dialysis and after the VR-intervention there were two patients who do not choose for peritoneal dialysis. Those patients did not choose for this treatment because peritoneal dialysis contains to many steps to perform. They indicated that they only want automatic peritoneal dialysis, which contains less steps to perform.

Noticed is that recent pre-dialysis patients were more unsure before the VR-intervention and after the VR-intervention. Furthermore, there were no noticeable differences between recent- and long-term pre-dialysis patients.

### *3.6 Suggestions for improvements*

The pre-dialysis patients reported suggestions for the information and VR (Table 9). The majority of patients suggested more information about automatic peritoneal dialysis. The patients would also add: (1) more detailed information about the treatment, (2) more advantages and disadvantages between the different treatments, (3) use a woman for the VR-intervention, (4) other locations (e.g. car) to dialysis, (5) and change the purpose: information into instruction. Suggestions for the improvement of VR were: (1) more comfortable glasses with a different type of material, (2) the possibility to look together, (3) and the use of a remoter. There were no noticeable difference between the recent- and long-term pre-dialysis patients.

Table 9

*Suggestions for improvements for the VR-intervention by pre-dialysis kidney patients (N = 23)*

	Recent pre-dialysis (n = 12)	Long-term pre-dialysis (n = 11)	<b>Total</b> (N = 23)	Example quotes
<b>Suggestions for the information about:</b>				
The APD machine	6	8	<b>14</b>	'More information if you want to dialysis at night (R9)'
Other locations to dialysis	2	1	<b>3</b>	'It looks so simple, I would like to see that it is so simple, for example dialysis in the car (R3)' 'How does he dialysis at work (R15)' 'The impact on my social life (R6)'
The treatment	3		<b>3</b>	'How he cleans the tubes of his stomach (R7)' 'He did not show how you had to administer everything (R9)'
Advantages vs disadvantages		1	<b>1</b>	'Show the advantages and disadvantages of each treatment (R6)'
Multiple genders		1	<b>1</b>	'Mabey you can use a woman for once (R1)'
Not in the first meeting during the pre-dialysis phases	1		<b>1</b>	'this was the first information I got, it was too soon (R15)'
The purpose of the information		1	<b>1</b>	'Use the film for training for the PD treatment, not as information (R6)'
<b>Suggestions for VR about:</b>				
The glasses	1	1	<b>2</b>	'A more comfortable helm or bandage instead of this glasses (R4)' 'Make the glasses lighter (R22)'
Looking together	2	2	<b>4</b>	'That you can look together (R5)'
A remoter		1	<b>1</b>	'a remoter to spit back pieces (R6)'

The dialysis patients (N = 6) who had experiences with peritoneal dialysis (not in table) suggested that the information should include: (1) a concrete time frame of the dialysis moment, (2) examples to dialysis in other locations, (3) information about the consequences (e.g. infections), (4) and information about automatic peritoneal dialysis. One patient would improve the VR-glasses with a softer foam.

## **4. Discussion**

The main objective of this study was to evaluate if VR is suitable for patient education. This was evaluated by the experiences of pre-dialysis patients and dialysis patients with a VR-intervention about peritoneal dialysis. It seems in general that patients were positive about the VR-intervention, however some critical notes were encountered. In the discussion, each sub-question will be discussed.

### ***4.1 Appreciation of the VR-intervention in general***

In general, all patients in this study valued the VR-intervention positively, with an average grade of 8 on a scale of 0-10. Besides that, the VR-intervention was recommended by all patients. Positive statements made by the patients were: it gives a total image and it is clearly understandable. These findings correspond with previous studies which have suggested that VR implicates a real image (Adams et al., 2018) and that the combination of sensory information and procedural information is most effective of understanding and then remembering medical information (Leventhal & Johnson, 1974; Green, 2013). A visual representation of medical information seems to help patients clearly understand the information. This could indicate that VR in patient education might be useful to help the patients to understand the information clearly. Besides that, health-related messages that are clear, simple and understandable in their wording, with the use of concrete and vivid language, would be more easily remembered (Sugiyama et al., 2011). So it seems that through the use of VR in patient education, the medical information was clearly understood by the patients and it might be better remembered. Further research is needed to investigate if VR in patient education helps better understand medical information compared to patient education that is given face-to-face by a health practitioners and which information is better recalled.

### ***4.2 Appreciation of the information***

Both recent- and long-term pre-dialysis patients positively appreciated the information and found the information useful. On one hand, it seems that almost all patients were sufficiently informed about peritoneal dialysis. On the other hand, a few patients could not determine if they felt sufficiently informed because they still had questions after the VR-intervention. The recent pre-dialysis patients were more satisfied with the information than the long-term pre-dialysis patients who were unsure about their satisfaction. According to Al-Maskari and Sanderson, (2010) satisfaction factors can be evaluated by an information retrieval system. This system evaluates satisfaction according to three criteria: (1) the suitability of a system in terms of the specific information retrieval tasks for which it will be used, (2) the systems task performance efficiency, (3) and the extent to which the system satisfies the information needs of its users. The third criteria can be used to explain the difference between recent- and long-term pre-dialysis patients. The information need of the recent pre-dialysis patient is quicker satisfied than the information need of long-term pre-dialysis patients. For recent pre-dialysis patients all information is quite new and they need time to process this information. Long-term pre-dialysis patients had more time to prepare themselves and might had more knowledge about peritoneal dialysis, so therefore they could have had additional questions that go more into detail about peritoneal dialysis. It is recommend to have a nephrologist present at the information session when the VR-intervention is used. The nephrologist can answer questions after the VR-intervention and give additional information about peritoneal dialysis. Nevertheless, this is only one explanation, other criteria and factors for the satisfaction about the information and the difference between recent and long-term pre-dialysis patients should be taken into account. Future research is needed to further explore the differences

between recent- and long-term pre-dialysis patients and which factors determine the satisfaction about the information.

Whereas in general almost all pre-dialysis patients appreciated the information, the dialysis patient who had experiences with peritoneal dialysis had more negative remarks about the information. The patient who had experiences with peritoneal dialysis indicated that the VR-intervention does not entirely correspond with their reality. According to them it seemed that some important information about peritoneal dialysis was not present in the VR-intervention and some information was not entirely correct. For the development of VR in patient education is recommended that the content should be pre-test through patients who have experience with the type of medical information or treatment.

Another interesting finding is that the majority of the patients would prefer more information about automatic peritoneal dialysis during the VR-intervention. In the VR-intervention automatic peritoneal dialysis is only briefly explained. The treatment automatic peritoneal dialysis is a continuation on peritoneal dialysis. First the patients starts with peritoneal dialysis and after four to six weeks, the patient can switch to automatic peritoneal dialysis. Nevertheless, nearly all patients seemed interested in this treatment. An explanation might be that automatic peritoneal dialysis takes place at night and gives the patient more freedom during the day. It is recommended to expand or develop a VR-patient education for automatic peritoneal dialysis.

#### ***4.3 Appreciation of the VR experience***

As far as we know, this is one of the first studies investigating the use of VR in patient education. Results revealed some important lessons, namely that we can infer that medical information can be transferred in such a way that the patient really experiences it. This is support by the majority of patients that experienced the VR as immersive. The dialysis patients reported that 'it felt as if they were present with him'. This finding corresponds to previous studies (Adams, et al., 2018; Paolis & Mongelli, 2015) which have suggested that VR creates a life-like experience. To get more insights in VR in patient education, additional studies will be needed to investigate the experiences of patients in patient education through VR.

Interestingly, patients indicated that you do not have to go anywhere. This was implicated by a few patients who had the experience of visiting another peritoneal dialysis patient at their home. Visiting another patient is for pre-dialysis patients most of the time inconvenient, uncomfortable and takes a lot of time. Through the use of VR it is easy to show the treatment. This finding is also supported by previous literature that VR creates a life-like experience (Adams et al., 2018; Paolis & Mongelli, 2015). It might indicate that VR in patient education about peritoneal dialysis can replace the home visits that are made during the pre-dialysis phase. It seems that the one of the goals of the VR-intervention can be reached through VR in patient education, namely that VR in patient education can ensure that time is saved and costs are reduced. To hospitals it is recommended to give the possibility to patients for a VR experience instead of home visit. A comparison study to further explore the effects between the VR experience and home visits is needed.

Another important lesson that was discovered during this study was that patients reported not to be distracted during the VR-intervention. A possible explanation for this might that the 'frame' of the VR-glasses encloses the eyes as a whole so that images and sounds from the environment will not penetrate the user. The user is therefore not distracted and can thus completely merge into the virtual world. This finding might indicate that the patients were more focused on the information provided in the intervention. Another possible explanation for

this finding might be the age of the patients in this study. The age of the patients is quite high, therefore it could be that the patients are quicker overly stimulated by the environment (Tripathi, 2013; Tanaka, Monahan & Seals, 2001). The VR-glasses can help the elderly patients not to be distracted and more focused on medical information. We could not find any comparable studies to this finding, however, one comparable practical situation was found which uses VR in elderly people with (incipient) dementia who are often easily distracted, confused and sleep badly (Treantcare, 2018). The purpose of VR was to get elderly calmer so that they have no distraction from their own environment. Overall, these findings might implicate the possibility that VR in medical information ensures that medical information is better transferred. Further experimental investigations are needed to explore the effects of not being distracted in VR in patient education.

Nevertheless, the results of this study tell us that for some patients the VR experience was more negatively. One- third of the patients indicated that VR is of no added value for them. The patients said that it would be the same if the film was shown to them on a TV-screen or PC. This assumption of the pre-dialysis patients is not based on actual facts, because to make such statement it is required to participate in an experimental study were first the VR-intervention is used and secondly a film on a TV-screen is shown, so a comparison can be made. Besides that, it could be that they say that it is of no added value, but unconsciously it was an added value. In addition, it seems that the recent pre-dialysis patients had more negative remarks about VR. This could be explained by the fact that recent pre-dialysis patients have been in the pre-dialysis phase for a short time, which means that they might be more tense and therefore are less open for new things, such as VR. It is recommended to offer the VR-intervention as a possibility to patients. A further study to compare the VR-intervention versus the intervention on a TV screen is suggested.

Another lesson that the results of this study showed us was that some patients experienced the VR-glasses as uncomfortable. This was indicated by that the glasses were too heavy or dropped. A possible explanation might be that the headband where the glasses are attached to were not tight enough. This may have caused the glasses to hang and create the experience that they were too heavy. This can easily be solved by tightening the headband. It also varies on each individual if the VR-glasses are experienced as heavy. Continued efforts are needed to make the VR-glasses more accessible for patients. Recent pre-dialysis patient reported more often that the glasses were uncomfortable. An explanation for this could be that the recent pre-dialysis patient were more tensed before and during the VR-intervention. This is related to the fact, mentioned above, that recent pre-dialysis patients have been in the pre-dialysis phase for a short time and are more tensed about what is happening to them. This finding suggests several courses of action for further research on this assumption. It is recommended to make sure patient are at ease and whether the glasses are comfortable for them during the VR-intervention. Daily research takes place to improve VR-techniques so that in the future a lighter pair of glasses will be used.

Some patients indicated that the glasses were too smothery. This was probably caused by the hot temperatures during this summer (2018). Another possible explanation might be that pre-dialysis patients were tensed during the VR-intervention or that the glasses did not entirely fitted, so that by breathing a little into the glasses, the fitting got a bit covered with smug. For this finding counts the same recommendation as mentioned above: 'make sure patients are at ease and whether the glasses are comfortable for them during the VR-intervention'.

Interestingly, the patients mentioned that they would like an opportunity for their partner or family member to see the information as well during the meeting. The patients found it important that their loved ones

also could take a look at the given information. This finding is in line with studies that show that it is important for patients to share medical information with their partners (Given, Given, & Kozachik, 2001; Zulman et al, 2011). For patients it is beneficial that relatives are also informed because patients might be tensed before and during the meeting with the doctor. Besides that, given information might be overwhelming and easily forgotten by patients. Relatives can support patients and listen along with the given information, initially two persons remember more than one (Davidson et al, 2007). The possibility to share information contributes to better patient education. The use of multiple VR-glasses or the opportunity to see the VR-intervention after the pre-dialysis patient is finished should be offered. Further research is needed to establish what kind of benefits the pre-dialysis patients experience of sharing the information about peritoneal dialysis.

Some of the patients reported symptoms of cybersickness during the VR-intervention. This finding is in line with previous studies using VR (Young, Adelstein & Ellis, 2006; Lin et al., 2002; Mollenhauer, 2004). Cybersickness occurs when there is a conflict between perceptions in different sense modalities or when sensory cue information in the virtual world is incongruent with what is felt by the body or with what is expected based on the users' history of the real world sensorimotor experiences (LaViola, 2000; Diels & Howarth, 2012). Weech, Varghese and Barneet-Cowan (2018) showed that cybersickness is partly caused due to the differences in how individuals use vision to control their balance. With this information, it is possible to refine this to rapidly assess an individual's tolerance for VR and tailor their experiences (Weech et al., 2018).

One patient reported symptoms of simulator sickness during the VR-intervention. Simulator sickness can be caused by imperfect hardware, system latency and frame rate variations (Lin et al., 2002). Nevertheless, simulator sickness can be reduced or removed by repeated exposure to VR (Bles & Wertheim, 2000; Bishop & Abid, 2018). However, we can assume that with the innovating techniques of VR, in the future the side effects of VR will not occur at all.

#### ***4.4 Perceived impact of the intervention***

For all pre-dialysis patients the perceived impact of the intervention was high. Whereas the intervention was able to create reassurance, increase knowledge and confidence in some patients (mostly long-term pre-dialysis patients) it appeared to increase worries, insecurities, confrontations and aversion in other patients (mostly recent pre-dialysis patients). Nevertheless, the recent pre-dialysis patients were satisfied about the information it had a high impact on them. That the recent pre-dialysis patient had more worries about the treatment, had more insecurities about the start of the treatment and were more confronted about the delivery and their illness can be caused by the grieving process. Previous studies have demonstrated that the loss process takes on average one year (Pool, 2010). In addition, the nephrologists indicated that when patients hear that their kidneys work for 20% or less, it has an enormous impact on them. So it seems a logical result that the intervention has a higher impact on the recent pre-dialysis patients. It should be investigated if there is a correlation between the patients' satisfaction about the information and their perceived impact of the information.

To discuss the perceived impact of the intervention on the pre-dialysis patients we can use the goals that had to be achieved with the VR-intervention, namely increase the patients' knowledge, reassure patients and increase the patient's confidence. One of the purposes of the VR-intervention was to gain more knowledge. On one hand, the results of this study showed that the patients gained more knowledge about the treatment and the hygiene that comes along with the treatment. Before the intervention patients had other expectations about the



treatment. The patients also gained more knowledge about the delivery quantity of peritoneal dialysis. On the other hand, patients were shocked and confronted about the delivery quantity. They did not expect that the delivery quantity was so much. This might implicate that the purpose of the VR-intervention; gain more knowledge (reducing the unknown) is realised. Despite the fact that the quantity delivery was experienced as shocking and confronting, it does implicate what the patient can expect. As mentioned in the literature review it is important to transfer medical information that corresponds to reality.

Another goal of the VR-intervention was to reassure patients about peritoneal dialysis. On one hand it seems that some patients were more reassured about peritoneal dialysis after the intervention. The patient is reassured about their freedom, the possibilities for holidays and that the dialysis takes place at home. This might implicate that the intervention shows the benefits of the treatment peritoneal dialysis. This finding is consistent with the predetermined goal of the VR-intervention. On the other hand, patients indicated to be unsure about not being able to perform all those actions. A possible explanation for this could be that patients could not identify themselves with the patient in the VR-intervention. According to Bussey and Bandura (1999) modelling is used to learn behaviour from peers. In this study, it might be possible that patients (with an average age of 67 years) cannot identify themselves with the patient (35 years old) in the VR-intervention. For elderly, it is hard to recognize themselves in the young patient. This could cause their worries to perform those actions, which can be underlined by the fact that patients indicated that peritoneal dialysis seems difficult to learn. Besides that, it seems that kidney failure occurs more often in elderly, therefore it is important to underline, during the VR-intervention, that both young and older people use peritoneal dialysis. This might help the patient to identify better. It seems that VR in patient education increases worries about the treatment. Future research should explore how the worries about the treatment can be decreased.

The last goal of the VR-intervention was to gain more confidence. A few patients indicated to be more confident about the treatment peritoneal dialysis. An explanation for this might be that those patients could easily identify to the patient in the intervention (Bussey & Bandura, 1999; Morgenroth, Ryan & Peters, 2015). This might indicate that patients see themselves carry out peritoneal dialysis. Nevertheless, many patients reported to be insecure. They were insecure about the start of the treatment. It seems a logical reaction that patients feel insecure after they are confronted with their illness and possible treatment through the intervention. The VR-intervention lets you experience how it is to dialysis. This can be a trigger for insecurities about when to start the dialysis. This reaction might implicate that VR in patient education gives a realistic and clear image of the type of treatment and illness. This finding corresponds with studies of Sales et al. (2011) and van Vliet et al. (2004) which state that it is important that the information corresponds with the reality. However, their insecurity might be caused by other factors in their environment. Future research is needed to investigate which additional factors are of influence on the patient's insecurities.

It seems that the goals of the VR-intervention are achieved. According to Bero et al. (1998) and Grol, (2001) requirements for good patient education are: (1) giving concrete guidelines or instructions that patients must follow for treatment or research (2) giving an explanation about the disease and the treatment, so that patients learn to understand the background and their consequences (3) give information about what patients can do to improve their illness themselves or to keep the illness under control. This might indicate that VR in patient education is suitable to inform patients. Nevertheless, this study did not do any pre-measurements about knowledge, reassurance and confidence. This means that we did not know how much prior knowledge, how

reassure and confident the patients were before the VR-intervention, so it is difficult to establish if any change is took place. To investigate these effects, further research is needed.

#### ***4.5 Suggestions for improvements***

The patients had some suggestions for improvements for the intervention and the VR experience. As mentioned before the patients want to add information about the automatic peritoneal dialysis. This finding, shed new light on the information needs of dialysis patients. Despite the fact that automatic peritoneal dialysis is only carried out after 4-6 weeks, they showed much interest in this treatment. It can be assumed that automatic peritoneal dialysis is even easier to carry out and offers more freedom. This information about automatic peritoneal dialysis in the VR-intervention gave the patients probably a nice prospect. It is recommended to expand or develop a VR-intervention for automatic peritoneal dialysis.

Another suggestion made by one of the patients was that the VR-intervention should not take place in the first information session in the pre-dialysis phase. This finding is also confirmed by the nephrologist and the researcher of this study. With one patient, the VR-intervention took place in the first meeting of the pre-dialysis phase. This patient was quite upset after seeing the VR-intervention. It can be assumed that it is of importance to first give an explanation about the illness and in another meeting explain the alternative treatments (VR-intervention). Based on all other patients-meetings that went well, which took place in the third or fourth meeting in the pre-dialysis phase, we can assume that the VR-intervention should be used during the third or fourth meeting in the pre-dialysis phase.

As mentioned before, the patients indicated that it would be great to use the VR-intervention together with their partner or family members. Studies suggest that it is good to share medical information with relatives. (Given, Given & Kozachik, 2001; Zulman et al, 2011). In addition, sharing information is beneficial for the patient. Therefore it is recommended that the nephrologist offers the possibility to use multiple VR-glasses or let the relatives use the VR-intervention after the pre-dialysis patient is finished.

#### ***4.6 Limitations***

The outcomes of this study need to be interpreted with caution. The average age of the patients is 67 years. Almost all of the manifestations of kidney disease are more common in the elderly (between 65 and 80 years of age). They are at greater risk and have a high incidence and prevalence of both the extreme problems – acute kidney injury and end-stage renal disease requiring renal replacement therapy (Winearls & Glasscock, 2011; Hsu et al., 2007). Elderly, in general, are constantly confronted with all kinds of loss experiences. Their physical and mental activities are reduced, their social network has shrunk and the older they become, the less activities they can perform. In addition, for elderly making a decision becomes increasingly challenging, not only because age itself precludes dialysis, but because of considerations of comorbidity and reduced overall lifespan. Besides that, the impact of dialysis itself on quality of life, becomes more complex with increasing age (Stevens, Viswanathan & Weiner, 2010). Which indicates that the patients in this study might have more worries, insecurities and fears. There is no answer to the question whether this process differs for young people. Emotional pain, grief and sadness is experienced by everyone in their own way (Adriaensen, 2006). To make the results of the study more generalisable a comparable study should take place between elder - and younger pre-dialysis patients. Furthermore,

further research is needed to establish an individual baseline for each patient to measure the grieving impact of the loss of their kidneys, so that the impact of recent- and long-term pre-dialysis patients can better be analysed.

Another limitation of this study was that only patients who were not too emotional about their loss of kidneys participated. Through this selection bias, the results in this study only account for a more stable group of patients. For those patients VR in patient education seems a suitable method. Nevertheless, also for patients in this study it seemed that losing the functioning of the kidneys remains a vigorous process. It should be further investigated whether VR in patient education is suitable for patients who are less stable.

Despite these shortcomings, the patients in this exploratory study were reasonably representative of the dialysis populations as a whole, the age range and baselines characteristics are in line with the renal registry data.

## 5. Conclusion

The aim of the present research was to evaluate the experiences of (pre) dialysis patients with a VR-intervention. The purpose of the VR-intervention was to better inform (reassure, knowledge, confidence) the patient and to make the pre-dialysis phase more efficient. The findings of this study showed that VR might offer a valuable contribution to better store and remember medical information. The most obvious finding to emerge from this study is that VR is not a one size fits all method. For two-third of the patients in this study VR is highly appreciated and it seems valuable to be informed through VR. One-third of the patients says that VR has no added value for them. Hospitals should offer patients the possibility to use the VR-intervention. The insights gained from this study may be of assistance to future research in VR in patient education. What is needed now is an experimental study involving VR in patient education versus patient education.

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## Appendices

### Appendix A

#### Interview Scheme (Dutch)

**Onderzoeker:** Bedankt dat uw mee wilt doen aan het onderzoek. U bent net voorgelicht door middel van de VR bril over buikspoeling. Ik zal u zo hierover een aantal vragen stellen, deze vragen zullen betrekking hebben op uw ervaring met de vr bril en de gegeven informatie. Er zijn geen goede of foute antwoorden het gaat puur om uw mening en ervaring. U heeft doormiddel van de toestemmingsbrief al toestemming gegeven om dit gesprek op te nemen. Ik wil u er nogmaals op wijzen dat u volledig anoniem blijft en verzamelde gegevens zullen niet met derden gedeeld worden.

#### *Topic 1: Demografische kenmerken*

- Leeftijd
- Geslacht

#### *Topic 2: Algemene indruk van de interventie*

- Wat vond u ervan?
- Hoe heeft u de VR-interventie ervaren?
- Wat voor cijfer zou u deze interventie geven op een schaal van 0- 10?

#### *Topic 3: Waardering van de informatie*

- Wat vond u van de voorlichtingsinformatie?
- Wat vond u er goed aan?
- Wat vond u er minder goed aan?
- Welke onderdelen van de informatie vond u positief?
- Welke onderdelen van de informatie vond u negatief?

#### Easy to use

- Heeft u alle informatie begrepen waarom? Waarom wel/niet?
- Vond u de vr voorlichting makkelijk te begrijpen of moeilijk?
- Wat (welke onderdelen of welke aspecten) vond u makkelijk?
- Wat (welke onderdelen of welke aspecten) vond u moeilijk?

#### Usefulness of the VR-intervention

- Hoe nuttig (of overbodig) vond u deze VR voorlichting?
- Wat is volgens u het belangrijkste nut?
- Welke onderdelen vond u het meest nuttig?
- Wat is volgens u juist niet zo zinvol aan deze VR voorlichting?
- Welke onderdelen vond u het minst?

#### Satisfaction of the information

- Welke vragen over buikspoeling had u van te voren? Heeft de VR-film u daar antwoord op gegeven? (zijn er nog meer vragen .. etc? doorvragen)
- Welke overwegingen/twijfels had u van te voren? Heeft de film die twijfels weg kunnen nemen? (had u nog andere vragen/ twijfels etc)
- Heeft u nu, na het meemaken van de VR, het gevoel dat je voldoende geïnformeerd bent?
- Indien nee, welke vragen zorgen of twijfels heb je nog?
- Voelt u uw nu, na het meemaken van de VR, in staat om een goede beslissing te maken?

#### Topic 4: Virtual reality ervaring

- Wat vond je van de VR bril?
- Hoe heeft u dat ervaren dat u zoon bril opkreeg?
- Wat vond u goed aan de bril?
- Wat vond u minder goed aan de bril?

#### Easy to use

- Hoe makkelijk of moeilijk vind u het gebruik virtual reality ?
- Wat of welke onderdelen daarvan vond u makkelijk?
- Wat of welke onderdelen daarvan vond u lastig of moeilijk? Wat vond je makkelijk?

#### Advantages and disadvantages

- Wat zijn volgens u de voordelen om via VRbril voorlichting te geven?
- Wat zijn volgens u nadelen om via VRbril voorlichting te geven?
- Wat maakt virtual reality anders dan een gewoon filmpje?

#### Topic 5: Impact and beliefs

- Wat voor effect heeft het zien van de vr voorlichtingsfilm op u?
- Zijn er nu u de film hebt gezien dingen die achteraf meevallen?
- Zijn er nu u de film hebt gezien dingen die achteraf tegenvallen?
- Waar had u van te voren niet aangedacht?
- Zijn er nu dingen waar u anders naar kijkt?
- Heeft u nieuwe kennis opgedaan?
- Bent u door de film gerustgesteld? Zoja waarover?
- Wekt de vr film nog zorgen op? Zoja welke?
- Wekt de vr film nog angsten op? Zoja welke?

#### Topic 6: Aanbevelingen en suggesties voor verbetering

- Zou u de vr film ook aanraden aan andere dialyse patiënten die moeten kiezen voor een behandeling voor nierfalen? (wie wel? Wie niet? Waarom wel/niet? )

- Vindt u dat we als Deventer ziekenhuis meer gebruik zouden moeten maken van VR?
- Zou u de manier waarop je bent voorgelicht ook aanraden aan andere patiënten?
- Zou u de vr film over peritoneaal dialysis nogmaals willen zien?
- Wat voor suggesties heeft u voor ons om de VR film te verbeteren?
- Heeft u verder nog dingen die u kwijt wil/opmerkingen of vragen?

**Onderzoeker:** Dan wil ik u bedanken voor uw deelname.